ECONOMIC BOTANY

Devoted to Applied Botany and Plant Utilization

Vol. 11 JULY-SEPTEMBER, 1957 No. 3

ECONOMIC BOTANY

Devoted to Applied Botany and Plant Utilization

Founded by

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Published by

The New York Botanical Garden

Advisory Editors

Economic Botany is published quarterly by The New York Botanical Garden, Bronx Park, New York 58, N. Y. Subscription price per annual volume everywhere is $[illegible]; price per single copy is $[illegible]. Subscriptions and correspondence should be sent to Economic Botany, The New York Botanical Garden, New York 58, N. Y., and checks should be made payable to Economic Botany. Typescripts should be double-spaced. Photographs will be considered only if of high photographic quality.

Published Quarterly one volume per year, January, April, July and October
Box 749, Lancaster, Pa.

Entered as second-class matter March 17, [illegible], at the post office at Lancaster, Pa., under the act of March 3, 1879.

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Piqui-á — *Potential Source of Vegetable Oil for an Oil-starving World*

Sir Henry Wickham achieved fame through his rôle in the introduction of the Brazilian Hevea rubber tree into Indonesia. Here is the story of another Brazilian tree of possible economic value which he and others endeavored to exploit but which has become an almost forgotten source of edible fats.

EDWARD V. LANE[1]

One cannot doubt that a substantial addition to the world supply of edible fats would bring great benefit to mankind, especially if such fats were to be produced within the tropics, where, among other dietary defects, the vast majority of the population suffers from a serious deficiency in fats. Such also was the firm belief of Henry Alexander Wickham during the First World War. But the story of piqui-á began half-a-century before.

As a fervent imperialist, Wickham always had in mind the introduction of new plants of economic value into various parts of the British Empire. In the early eighteen-seventies Wickham was living near Santarem, Brazil, planting coffee and tobacco. From time to time he despatched to the Royal Botanic Gardens, Kew, botanical specimens which he judged might be of value for propagation in British tropical possessions. The vegetable product to which Wickham most persistently directed the attention of Kew was the fruit of piqui-á, variously spelt pekea, pekia, pichia, pequia, paqui-á and pequi. The first mention of this commodity occurs in the Museum Entry Book of Kew under the date June 21, 1876, where it is recorded that a sample of butter from the boiled fruit of *Caryocar brasiliensis* had been presented by H. A. Wickham. The Kew Report for the year 1876 records the receipt of the seeds of the same tree in addition to the butter. Henry Wickham had arrived in England in mid-June, 1876, with his 70,000 seeds of *Hevea brasiliensis* which were destined to initiate the great rubber plantations of Tropical Asia. In a letter of July 26, 1876, addressed to Dr. Joseph Hooker, Director of Kew Gardens, Wickham wrote: " May I be permitted, sir, to call your attention to the Piquiá (seeds of which I brought over with me) as I believe it would be a most valuable timber-tree being very durable &, for a hard timber, quick growing. A very large quantity of pure fat or butter (I deposited a specimen of this in the Museum) is very easily to be extracted from the fruit.

" I would like to solicit your attention to some other S. American trees & fruits if I knew that you would desire it ".

A few days later (1st. August) Wickham wrote again to Dr. Hooker: "I have already mentioned the Piquiá tree—I do not know if the seeds deposited in the gardens are coming up yet ". A marginal note on this letter, probably added by William Thiselton-Dyer, the Assistant Director at that time, gives the name *Caryocar brasiliensis* as the probable source of piqui-á.

For many years, however, the true na-

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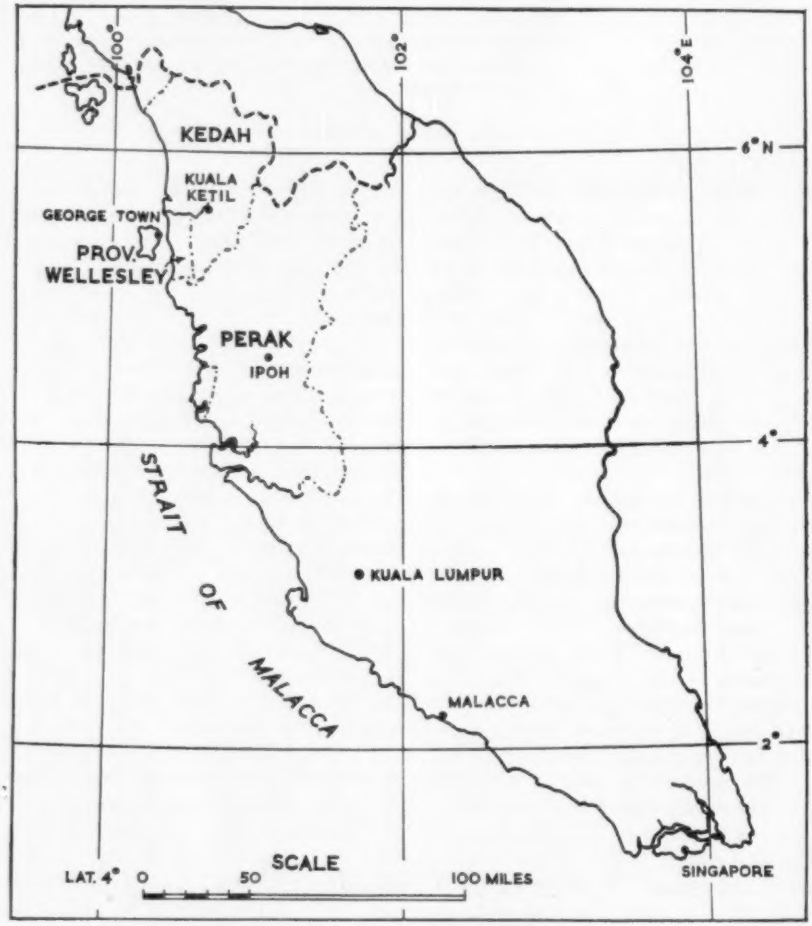
ture of the piqui-á tree was in doubt. In August, 1906, Wickham told the Director of Kew Gardens (Dr. David Prain) that it was unlikely that the piqui-á tree had been botanically determined, but that it should not be difficult to secure specimens of its seeds for systematic cultivation. "I believe the natural habitat'", wrote Wickham, "to be a somewhat circumscribed one; i.e., it is one of the chiefest trees of the forest covering the broad plateaux dividing the Tapajos from the Zingu tributaries of the Amazon. The soil of this well drained wide extending forest covered table-land is stiff soil not remarkably rich, but deep and uniform in character. The Piquiá found growing in this unbroken forest rivals all the trees therein attaining circumference to upward of 12 ft.; the for-



Map of Malaya

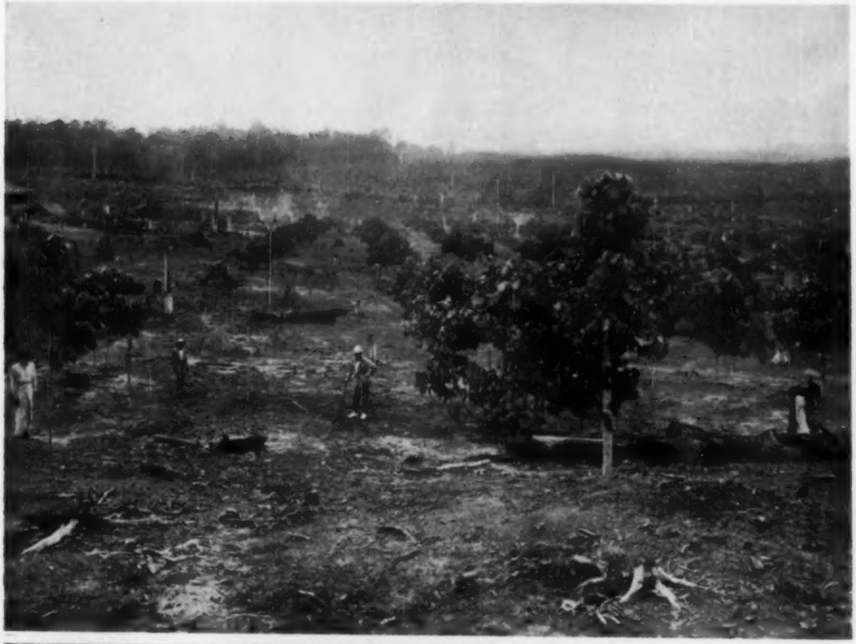


FIG. 1 (Upper). Piqui-á trees on part of the Birkhall Estate, Kuala Ketil, Kedah State, Malaya, early in 1922. The view gives some indication of the extensive clearing of land at that time for the project.

FIG. 2 (Lower). Piqui-á seedlings in March, 1920, growing among young *Hevea brasiliensis* trees. The piqui-á seeds were sown in the baskets in September, 1919.

est plateaux . . . present an escarped face which follows at greater or less distance & abuts steeply on to the . . . marginal plains of the great rivers [2]. . . . At one point the abutment of this table-land comes within a few miles of the town of Santarem situated at the junction of the Tapajos with the Amazon. The portion of the table-land at this point is known among the local Tapuyo Indians as the 'Piquiá-tüba', on account of the prevalence of the tree. Hence from this place it could readily be got".

Dr. Prain, replying in a letter of 14th. August, 1906, thanked Wickham for his letter, but told him that the piqui-á could not be identified, as there was no specimen in the possession of the Kew authorities, although they knew of similar, but not identical, species of *Caryocar*. The Director was therefore writing to Manaos for specimens from which he could determine, if possible, what the tree really was, and secure a supply of seeds for cultivation. He also quoted Bates' reference (in his "Naturalist on the Amazons") to the piqui-á. Wickham confirmed this as a probable reference to the same tree, and added: "Further on I see Bates mentions the locality, 'Piquiátuba', which means in the Tapuyo Indian, 'the forest of the Piquiá'".

More than ten years passed before any further developments connected with piqui-á could be reported. In February, 1917, Henry Wickham obtained from the Economic Museum at Kew a little of the butter he had deposited there in June, 1876. He sought to investigate its commercial possibilities. In response to his suggestion, Dr. Prain agreed to obtain an analysis of the piqui-á oil, but first requested the return of the sample previously handed to Wickham, so that the Museum specimen should not be reduced more than was absolutely necessary. Wickham thereupon wrote: "I should be very glad if you will let me know if you are able to let me have the *analysis* of my sample of the Piquiá fat in your hands. I do not consider it a fair thing to ask me to give back the very small sample-tube which I have—I am being delayed by want of the promised analysis".

In a long letter of 17th. April, 1917, to J. A. Greene, at Sardinia House, London, Wickham made clear his extraordinary faith in the value of this new product, to which he had first called attention over 40 years before. It demonstrates his determination to be a successful pioneer in the development of British possessions in the Tropics, by adding vegetable oil production to the great rubber plantation industry, of which he regarded himself as the prime initiator. His advice in 1876 had been ignored in the propagation of *Hevea brasiliensis*, and he held what amounted almost to an obsession—a conviction that others had gained the reward rightly due to himself. Piqui-á, therefore, was to establish his fortunes and enhance his reputation as an authority on tropical cultivation. He realized, of course, the paramount importance of adequate supplies of vegetable oils to a nation at war and threatened with imminent disaster by an unrestricted submarine campaign. A few quotations from the letter to Greene are very apposite:

"The value of a matter of standard purity in a plantation source of vegetable oil and fats can hardly be questioned—as without doubt it is the great coming industry. It may be reckoned a matter of at least equal magnitude to that of the Para rubber [3] . . .".

"Reckoning the fruit as giving some

[2] Wickham uses almost the same words in describing the locality from which he collected his *Hevea brasiliensis* seeds in 1876, in his book "On the Plantation, Cultivation, and Curing of Pará Indian Rubber" (1908), page 5.

[3] The serious shortage of fats in the period following the Second World War (1939-1945) makes Wickham's views almost prophetic.

FIG. 3 (Upper). The first piqui-á tree planted on Birkhall Estate, February 5, 1920, photographed the following October 5. Joseph Cadman at the right.

FIG. 4 (Lower). The oldest piqui-á trees on the estate, February 5, 1923, when they were exactly three years old. Note the marcottage p opagation on the right-hand branches.

¾ lb. of fat, the yield per acre [4] should be from 1300 lbs. to ½ ton, it will therefore be at once apparent that this greatly exceeds any existing source of supply—coconut (copra), palm kernels, etc., quite apart from the exceptional purity and therefore higher value of the product . . . .

" As to the value of this fat, as a food product, and as a batter or cooking fat; I myself used it year in and year out when living among the Indians ".

On 21st. April, 1917, Dr. Prain drew up a précis of all of the information about piqui-á available at that time. He pointed out that from 1876 onwards there was not reason to doubt that the fat was probably the product of some species of *Caryocar*. The tree had not been botanically determined, solely because neither Wickham nor any subsequent traveller had submitted botanical specimens known to have come from the tree—apart from the seeds Wickham had brought in 1876, and unfortunately none of these had germinated and none had been preserved. Extensive correspondence with British Consular authorities in Brazil had brought no reliable information, none of the Consular officers being able to secure specimens of piqui-á. " The only way in which it seems likely to establish the identity of the tree ", continued Dr. Prain, " is to visit the localities in which it is believed to flourish and to bring adequate material for its determination ".

On 24th. April, 1917, Walter Fox, a botanical expert of Kingston Hill, agreed to travel to Brazil in October of that year, in order to find out everything possible about the fat-producing tree, and to procure as many seeds as possible with a view to their introduction to the eastern tropics. Mr. Fox did not carry out his mission, however, possibly because his terms—one hundred pounds per month free of income tax, all travelling and other expenses paid, and a policy of insurance on his life for the duration of the trip—were regarded as excessive.

At the end of April, 1917, Sir J. J. Dobbie, of the Government Laboratory in Clement's Inn Passage, Strand, London, sent to Kew the results of the analytical examination of the fat presented to the Economic Museum by Wickham in 1876. " The sample was of a good white colour ", stated the Report, " with only a slight yellowish streak down one side. It had a strong odour suggestive of rancid nut-oil, and its taste was bitter and like that of tallow. . . . The results (i.e., of the analysis) are not in accordance with those of any fat of which there is any record. They are, however, so abnormal in character, that they cannot be accepted as representing the fat in its fresh condition. The fat has apparently undergone oxidation to an unusual degree, with the result that most, if not all of the figures have been very seriously affected, and it is impossible from the examination of this rancid and oxidised specimen to draw any definite conclusions as to the character of the original substance, or to express any opinion as to its commercial value ".

The substance of this Report was forwarded to Henry Wickham from Kew and must have proved very disappointing to him, although he probably realized that such opinions were to be expected from the examination of fat that was over 40 years old. Failing to effect a satisfactory agreement with Walter Fox in the matter of procuring piqui-á seeds from Brazil, Wickham called to his aid Joseph Cadman, whom he had first met at the Royal Empire Society—of which organization both men were ardent sup-

[4] With 40 trees per acre—the exceptionally wide half-chain spacing that Wickham always advocated for the planting of *Hevea brasiliensis*, on the ground that it is a great forest tree.

FIG. 5. A five-year-old piqui-á tree in March, 1925. W. M. Thomson, the propagator, stands under the tree.

porters—in the early days of the 1914 War.

Joseph Cadman,[5] born on 29th. May, 1871, at Newport, Monmouth, was exactly to the day 25 years younger than Henry Wickham. From 1895 Cadman served as a bank clerk, at first in India, then in Nigeria. His experiences overseas gave him an absorbing interest in tropical agriculture, and when he was

[5] Details of Joseph Cadman's life were supplied to the present writer by Cadman himself.

transferred to the London Head Office of the Bank of Nigeria, he could not settle down to the humdrum life of a London bank. Wickham and he quickly became very close friends, and Cadman, as the younger man, naturally undertook some of the more exacting tasks involved in Wickham's plans for the exploitation of tropical oil-seeds. Wickham, indeed, often spoke of Cadman as his "successor in experimental planting". Both men co-operated very closely until Wickham's death in 1928, and both suffered the same disappointments and setbacks. Cadman, furthermore, received virtually no financial reward for all his pioneering efforts, and he died in indigent circumstances in March, 1941.

In June, 1917, Cadman, acting on behalf of his friend, made contact with the British Government on the subject of piqui-á. The following is a letter from the Ministry of Munitions of War, Department of Explosives Supply (Oils and Fats Branch):

"Dear Mr. Cadman,

With reference to your visit on the 19th., I brought the matter before Lord Leitrim of the Colonial Office to-day, and he instructed me to ask you to lay all the information you have before him on the subject of the Oil-bearing fruit tree . . .".

The letter was signed by Alfred Bigland, M.P., for Birkenhead. He was likely to be keenly interested in Wickham's piqui-á, for he was a strong supporter of all Imperial projects and had published many pamphlets on questions of Empire affairs, Imperial Preference, and Tariff Reform.

On 11th. July, 1917, Cadman received a letter from the Colonial Office, acknowledging his application for Government financial aid for the introduction of the South American piqui-á edible oil-bearing tree into cultivation in the British Empire, and informing him that expert advice was being sought on his proposals. Within the next fortnight Wickham himself had begun negotiations with the British North Borneo Company, with the object of planting the piqui-á tree in British North Borneo. Unfortunately, Wickham could not accept the stipulations of the Company and the project came to nought.

On 13th. August, 1917, Wickham, persistent as ever, approached the India Office with a view to securing in Burma a block of land suitable for plantations of piqui-á. Owing to the difficulties inseparably connected with the initiation of a new tropical culture in wartime, however, no definite steps were taken to establish the new oil tree in Burma, and there is no evidence of any fresh piqui-á developments until towards the end of the First World War.

On 9th. October, 1918, Henry Wickham brought to Kew two leaves and six seeds of the piqui-á tree, which he had obtained from Brazil through the agency of Messrs. Edward Boustead and Company, of 149 Leadenhall Street, London. The seeds were embedded in piqui-á fat inside a small tin box. Three seeds were handed to the Curator for planting, two were kept at the Museum, and one was given to the Herbarium. From the leaves the authorities at Kew were able to identify the tree as that of which they had had similar specimens collected by Burchell from a young plant near the city of Para. Dr. Richard Spruce had collected other specimens near Barra on the Rio Negro, thus affording demonstration of the wide range of the species —contrary to Wickham's belief. The piqui-á tree was thereupon botanically determined as *Caryocar villosum*, which had indeed been recorded from French Guiana and from various places in the Amazon Basin as far inland as the Purus River.

Caryocar villosum is a tall tree, upwards of 150 feet, the trunk attaining a height of about 60 feet beneath the low-

FIG. 6 (Upper). A strip of bark being removed from a branch of piqui-á preparatory for marcottage.

FIG. 7 (Lower). A ball of solid soil molded around the bared stem.

est of its widespread branches, and a diameter of from three to five feet. It is not unlike a giant horse-chestnut tree in appearance, and furnishes excellent timber. It is, indeed, one of the most important timber trees of the upland forests of the Amazon region. The wood is hard, strong and tough, owing to its interlaced fibres. It is valued in particular for the framework and flooring of ships and boats, for the hubs and felloes of wheels, for piles, piers and many other heavy structures.

The large leaves of *Caryocar villosum* are trifoliate; they have well-marked veins and serrated edges. In the Amazon country the leaves fall about the end of the northern winter, and in July the tree puts forth new leaves. Shortly afterwards the yellow flowers appear in bunches. The sub-drupaceous fruits ripen between December and April, the time varying according to the locality, and are commonly sold in the markets of Para and other towns of Brazil. They are very palatable after boiling in water containing a little salt, and are generally sold in the cooked condition. The flesh of both fruit and kernel is edible. The fruits are globular, with a diameter of four to four and one-half inches, tending to become elongated if there are two or more seeds in the fruit. The outer layer of the pericarp, which is about one half-inch in thickness, is light brown and of smooth texture.

Caryocar villosum is closely related to *Caryocar nuciferum*, the tree which produces the souari nuts or butter-nuts of commerce. There are two varieties of piqui-á in the eastern Amazon region, but the only apparent difference is that one yields white-fleshed fruit, the other yellow.

When Wickham brought to Kew in October, 1918, the specimens supplied by Messrs. Edward Boustead, it was the first occasion that seeds of *Caryocar villosum* had ever been received or described in England, and it was found that they did not belong to the tree previously referred to by Wickham. He had described his piqui-á seeds as covered with spinous fibres and had actually left at Kew a drawing of the fruit showing a spiny stone in the centre of the oily flesh. It was further observed that the fat of *Caryocar villosum* was yellow, whilst that submitted by Wickham in 1876 was white.

The next important step in pursuit of Wickham's long cherished desire to introduce the piqui-á tree into some British territory for the production of fat, was the formation, shortly before the end of the War in 1918, of a small syndicate called the Irai Company, Limited—the name "Irai" being derived from one of the Conflict Group of coral islands, situated off eastern Papua, in which Wickham had lived some 20 years previously. The two leading members of the syndicate were naturally Henry Wickham and Joseph Cadman. The Irai Company had an initial capital of £20,000. Cadman undertook to bind himself for a term of ten years to pass over to the syndicate all fresh cultures that he might be able to introduce, as well as all others then in his possession. The syndicate was to plant nursery estates for the various new cultures; it was to contract with planting companies to supply plants at an agreed cash price and at an agreed percentage of the crops harvested for a period of years, the selling of such crops to be under the control of the syndicate. The profits of the syndicate would be derived from planting and supervision fees, from the sale of plants, and from the marketing of produce and the flotation of subsidiary companies.

As Henry Wickham was 72 years of age, too old to undertake the task himself, Joseph Cadman was commissioned to go to Para and Santarem in December, 1918, as an agent of Messrs. Edward Boustead, to collect seeds of the piqui-á tree and also of several other trees. Cadman paid two visits to Brazil within a

few months, and whilst there he made useful contacts in Para with Godfrey Davidson, a trader, who later, in 1919 and again in 1920, despatched other seeds to London. A letter dated 30th. June, 1919, from Davidson to Cadman, hints at trouble with the Brazilian authorities: "I must congratulate you", wrote Davidson, "upon having completed your 'work' so neatly and quietly.

FIG. 8. Sackcloth tied around the soil-enclosed marcottage.

After the fuss that the local big-wigs made upon your first visit I very much doubted your ability to come back a second time and do all that you have done". Cadman had, indeed, collected, in addition to piqui-á, the seeds of nine other trees, some important for their fruits, others for their timber, and a few for both products.

Apart from piqui-á, Cadman was most enthusiastic about batiputa (*Ouratea parviflora*), a small tree or shrub of northeastern Brazil, the seeds of which he had obtained in the region of Pernambuco. Of the batiputa, Cadman wrote: "This is a shrub growing to maturity in a remarkably brief time. It yields a large crop of oil-bearing berries in clusters in its second season after planting from seed. The oil is edible and of notable quality as may be seen from the accompanying Analyst's Report referring to Sumatra Palm Oil, a description given for obvious reasons when submitting the sample for analysis [6]. This oil is generally used for all culinary purposes in the localities where the shrub is found. I consider that the shrubs could be planted in nine feet triangles giving

[6] "Sumatra palm oil" is a pseudonym intended to conceal from possible rival producers the true nature of the commodity.

over 600 to the acre. Each shrub is estimated to yield 3 to 4 pounds of oil exclusive of cake. No heavy pressing or crushing is required. The oil is contained in the soft pericarp and can be run off on a commercial scale by means of steam-jacketed vats or vacuum pans. I would particularly emphasize the importance of this shrub as offering a source of rapid and substantial revenue and apart from distributable profits being a means of accumulating funds for dealing with the further cultures it is intended to secure ".

The Analyst's Report [7], to which Cadman refers, states that: " The sample of Sumatra Palm Oil [8] is certainly extraordinarily good, quite suitable for edible purposes and in fact is quite an unusual sample of Palm Oil. Its exceptionally low content of free fatty acid (which has to be extracted before the oil can be rendered edible), is a point very much in its favour ". The concluding words of the Report foreshadow one of the prime reasons for the failure of the Irai Company: " Just at present the market for edible fats is lower than the market for many technical fats. In normal times we should think your sample showing 1.40% free fatty acids would be worth £4 or £5 per ton more than ordinary grades of Palm Oil ".

Cadman does not appear to have planted batiputa in Malaya; but in September, 1923, he took to British North Borneo seeds of batiputa which he had obtained from the Goyanna plateau, some 40 miles north of Pernambuco. He claimed to have successfully planted the seeds on the Sapong Estate in North Borneo; but in order to conceal the true nature of the commodity until complete success had been assured, he called the plant " sebolga "—a name that he had probably derived from the Spanish and Portuguese " sebo ", meaning "fat ". With the failure of the Irai Company six years later there disappeared any hope of success during that decade for batiputa as a source of vegetable oil in North Borneo.

It is clear that the plans of the Irai syndicate, inspired by Henry Wickham and Joseph Cadman, were most ambitious. Having secured seeds of the varieties of trees selected for exploitation in the eastern Tropics, Cadman undertook to establish them in Malaya. He was fully confident of success. Of the trees in their Brazilian homeland, he wrote: " No attempt has been made to plant and tend them as those terms would be understood by us. Their products are collected from the wild trees in the same way that rubber was obtained before its introduction to the East. It would be superfluous to emphasise the marked benefit derived by species when transplanted within their own latitudes from one hemisphere to the other, though I may perhaps instance such well-known cases as Hevea Rubber and Cinchona from the Amazon to the East, also coffee from Asia to Brazil, brown trout from Scotland to New Zealand, and weakly youths from Europe to the Antipodes. In each instance a wonderful improvement in growth and stamina has resulted ".

In September, 1919, Joseph Cadman arrived in Malaya, and his piqui-á and other seeds were germinated on Malakoff Estate, Province Wellesley. The resultant seedlings were successfully planted out and established on the Birkhall Estate, Kuala Ketil, in Kedah State, during the year 1920. At the Birkhall Estate Cadman at once began work on forest clearance as a preliminary operation to the planting of piqui-á as the principal crop, with other trees on experimental lines. He engaged William Murray Thomson as propagator. A photograph, dated 5th. August, 1920,

[7] Messrs. Godlake and Nutter, 14/20 St. Mary Axe, London, E.C., 20th June, 1922.

[8] The oil of the batiputa tree.

shows that they then employed 41 workers—Malays, Chinese and Tamils. The cost of land clearance alone must have been extremely great, as a very large acreage was involved; but the bulk of the task was completed within the first year, and the first two piqui-á seedlings were planted out on 5th. February, 1920, amidst a chaotic mass of ugly tree stumps and scattered logs. Seeds had been sown in baskets in a nursery bed among young *Hevea* trees in September, 1919, and early in 1920 several hundred piqui-á seedlings were ready for transplanting to the main estate. Within three years the first two piqui-á trees referred to above had reached a height of about 20 feet, and two years later had fruited.

Besides the planting of seeds, a good deal of propagation was carried out by marcottage[9]. This is a system commonly practised in the Tropics for the propagation of fruit trees when reproduction from seeds or cuttings may be unsatisfactory. The bark is removed from a section of a branch, this section is wrapped in moss and then enclosed in soil. Sackcloth is tied around the ball of soil which is kept moist by water dripping from a can fastened above it, or by a length of absorbent wick in contact with the sacking and with the water container. In the wet season this artificial watering would be unnecessary.

FIG. 9. A small nursery of young 1927 rooted marcottes.

[9] " Marcottage " is the French term for propagation by layering. Marcotte = layer (horticulture).

The branch so treated readily produces roots within the soil, and it is usual to wait until they show through the sacking before severing the branch and planting it as a separate marcotte. During marcottage the branches are supported by sticks fastened to them.

The piqui-á marcottes at Birkhall Estate were first planted in a nursery bed before transplantation to the Estate. In the earlier period, when seeds were not plentiful, many trees were successfully grown in this way, although those grown from seed were more satisfactory and involved much less trouble and labour.

W. M. Thomson, in a report of 1928, points out that after eight years the trees planted out in 1920 had reached a height of more than 40 feet and that fruits were numerous, providing a source for experimental manufacture and also furnishing many seeds for future plantings. He gives an interesting description of the flowers and fruits of the piqui-á: "The tree when mature flowers once a year between March and June and immediately following new season's growth, after defoliation, as in the case of Rubber. The flower is an upright raceme, or spike, coming from the terminal bud of a branch, and this flower spike is composed of about thirty or forty florets. These florets begin to develop first from the base of the spike, i.e., the small flowers at the base develop and open whilst those near the top of the spike are still very immature. In this way one to four florets are due to mature daily on the raceme.

"The flowers are nocturnal and begin to open as darkness gathers, being full out between the hours of 9.30 p.m. and 2.30 a.m. at which latter time these full blown flowers fall to the ground. This means that there are only about five hours wherein pollination of the female organ must take place if fruit is to be expected. The florets are hermaphrodite, i.e., combining the two sexes. They have four pistils (female organs) and about two hundred and fifty stamens (male organs), and it is these latter which give the beauty and grace to the flowers as a whole. The colour is pale primrose yellow, and the flower develops a strong objectionable odour not unlike boiled cabbage water or decayed vegetable matter . . . .

"The fruits when mature fall to the ground during the months of October and November. They are then gathered and brought to the factory. The fruits are large and fleshy, weighing on an average eleven or twelve ounces. Some weigh as much as sixteen ounces. After reaching the factory the fruits are cut open and inside we find large kidney shaped nuts covered with a coating of pale yellow fat. The number of these nuts vary from one to three, although there is a possibility of the fruit containing four nuts. These nuts with their coating of fat are then put into a decorticator and brushed clean of all fatty substance".

The decorticator was especially designed for work on the Birkhall Estate. It would take a charge of at least 100 nuts and brush them clean within ten minutes. The fatty substance—a kind of 'cheese'—was collected and dried to a meal-like consistency. The oil was extracted from the meal by the solvent process.

Unfortunately, Sir Henry Wickham [10] died before the success of piqui-á oil production could be assured. In August, 1928, only one month before his death, the Annual Malayan Agri-Horticultural Show was held at Ipoh, in Perak. For the first time a comprehensive exhibit of piqui-á was displayed, comprising seedlings, fruits (immature in that month, but of fair size) nuts from the previous (1927) harvest, and a quantity of fat or

[10] He was knighted in the King's Birthday Honours, 1920, "for services in connection with the rubber plantation industry in the Far East".

FIG. 10. Flowering spikes of a piqui-á tree, April, 1925.

oil in tins and bottles. The fat obtained from the pericarp of the fruit was sweet and revealed no tendency to become rancid; it was obviously a splendid substitute for dripping or even for butter. The Report of the Show stated that a good deal of secrecy was being observed about the piqui-á tree, but that photographs and the fruits themselves furnished evidence that the tree was flourishing in the climatic and soil conditions of Malaya. The Malayan Agri-Horticultural Association awarded a special prize (Silver Medal) to the Irai Company for its piqui-á exhibit.

Despite the success achieved in the

Malayan exhibition, however, an Analyst's Report[11] of 4th. October, 1928, shows that the fat produced on the Birkhall Estate was not of sufficiently high quality for the competitive market. The analyst was impressed, nevertheless, by the fact that, although those operating the plant for extracting the oil were inexperienced in such work and their product was in consequence unsatisfactory, yet the results were encouraging. The Report continues: "It is for this reason that I hope you will not be disappointed in the small quantity of fat they have produced, which is not a commercial product and which, if it were in such a quantity as to render its sale necessary, would only be a waste product".

Fig. 11. Foliage and inflorescence of piquí-á.

[11] E. R. Bolton, 6 Milner Street, London, S.W.

The specimens of fat examined were found to contain between 61.6% and 65.5% of free fatty acids—in striking contrast with the unusually low content

of free fatty acids in batiputa oil (1.40%). The high percentage of acids in the piqui-á oil was undoubtedly due to the fruits having been in store for a long time before treatment. The piqua-á fat was, furthermore, of an unattractive brown colour, probably because of burning. Apart from these defects, the fat was relatively free from impurities; but the amount produced represented a low yield for the quantity of nuts treated. According to W. M. Thomson, the cost of harvesting, decortication and manufacturing reached the high figure of 47s. 0d. per cwt.

In June, 1929, there appeared in the Malayan Agricultural Journal an article on "Piqui-á Fruit Oils" by C. D. V. Georgi, an agricultural chemist. He reported that in the nine years since their planting, the trees had made good growth,, having reached a height of about 50 feet with a spread of branches approximately equal to their height. He pointed out that the fruits, like those of the African oil-palm, contain two oils, one in the pericarp of the seed, the other in the kernel. The seeds, 2¼ to 2½ inches long, are surrounded by the inner layer of pericarp, ⅛ to ¼ inch thick, which is yellow and contains oil, amounting (if moisture is discounted) to 72.30% of the inner layer. Analysis shows that this pericarp oil resembles palm oil and could be used for similar purposes. It is easily bleached, producing a high-quality oil that would be a suitable basis for edible fats. Experiments revealed, however, that it would be necessary to treat the ripe fruits without delay, owing to the presence of an enzyme which causes free fatty acids to develop on storage.

The kernel of the nut, two inches long, three-quarter inch thick, contains 61.40% oil on a moisture-free basis, yellowish and semi-solid at ordinary temperatures. It resembles the oil from *Caryocar tomentosum*, sometimes known as "souari fat", and could likewise be utilized for edible purposes. The kernels of *Caryocar villosum* are highly esteemed as dessert nuts in South America and the West Indies.

All plant fats, in the mature fruits, are of negligible free fatty acid content and perfectly fresh. They degenerate, owing to enzymic action or to atmospheric oxidation, only as a result of keeping in unsatisfactory conditions. With fruit-flesh fats in particular, the pulp must be sterilized and the fat extracted from it immediately after the fruit has been gathered. Seeds or kernels, similarly, should be properly dried and kept dry until they reach the fat-extraction factory.

The presence of acidic or of oxidative rancidity in any fruit fat merely shows that it has been mishandled, and is of no significance otherwise. The criterion of a fat is the composition of its total fatty acids in combination as glycerides, not in the condition of any one particular sample.

The composition of the fatty acids in both pericarp and kernel of piqui-á fruits has been accurately determined. Their resemblances to, and differences from, those of a typical palm oil are seen in the following figures [12]:

Combined fatty acids, percent	Piqui-á		Palm oil, Malaya plantation
	Pericarp	Kernel	
Myristic	1.5	1.4	2.5
Palmitic	41.2	48.4	40.8
Stearic	0.8	0.9	3.6
Oleic	53.9	46.0	45.2
Linoleic	2.6	3.3	7.9

Broadly, all are similar, with palmitic and oleic acids, each, forming 40 to 50% of the total fatty acids. For edible purposes piqui-á fats should be somewhat better than palm oils because of their lower content of combined linoleic acid which is subject to oxidative rancidity.

Henry Wickham's faith in the value of the piqui-á nut as a source of edible

[12] Supplied by Professor T. P. Hilditch of Liverpool University.

fat would appear to be fully justified; but, as we have noted, he died before any worth-while developments. The Irai Company did not long survive him; it was wound up in 1929. This unhappy failure resulted from a combination of causes. With the meagre capital available, the Company was unable to pass beyond the experimental stage of manufacture, and the indications of low yield per acre, coupled with difficulties in preparing a marketable commodity, were not very encouraging. Undoubtedly the greatest obstacle to the success of piqui-á was the competition of cheaper and more abundant vegetable fats and oils from other sources during a period of depressed prices in world markets. Furthermore, there was trouble in the relationships between Cadman and Wickham, on the one hand, and the Board of Directors of the Irai Company on the other. In September, 1924, Cadman complained in a letter to the Chairman of the Company that certain proposed alterations in the share capital would be "very harsh and even unfair". He claimed that Sir Henry Wickham and he himself should "have an opportunity of reaping our fair share of the reward towards which all our efforts were directed".

Fig. 12. Piqui-á flowers, the morning they fell from a tree, April, 1925.

Further information concerning the fate of the Brazilian trees introduced into Malaya by the joint efforts of Cadman and Wickham is contained in two

Reports from the Department of Agriculture, Kuala Lumpur, F.M.S., despatched to the Royal Botanic Gardens, Kew, in April and September, 1936. The information was passed on to Joseph Cadman with the comment of the Director of Kew that the Reports were " quite satisfactory, as far as a growth point of view is concerned ". Pointing out that the Birkhall Estate was now known as estimated the total crop to be between 40,000 and 50,000 fruits. Records of yield per acre or per tree are not available ".

A letter (dated 29th. December, 1952) to the present author from E. F. Allen, Senior Agronomist of the Department of Agriculture, Kuala Lumpur, furnishes the most recent information available about piqui-á:

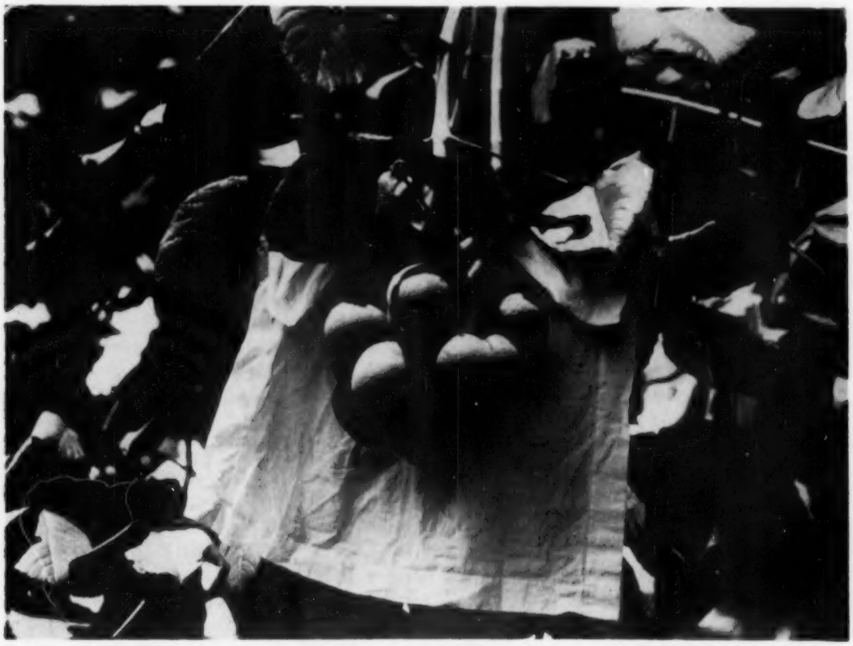


FIG. 13. A cluster of 12 piqui-á fruits, April, 1925.

the Stothard Division of Malakoff Rubber Estates, Limited, the Report continues: " The Piqui-á (*Caryocar villosum*) has continued to thrive exceedingly well, especially on the more elevated areas. Of the original stand, some 1,600 trees are being maintained and on another area, which has not been up-kept for some years the trees are growing well under semi-forest conditions. In 1935 the Acting Manager of the Estate

" The Pequia Nut trees on the Stothard Division of the Malakoff Estate were abandoned prior to the Japanese occupation and the few trees that survive are now neglected. There has been no post-war Malayan production and hence no export.

" Two Pequia nut trees are maintained at the Federal Experiment Station, Serdang, and these fruit regularly but there is no demand for planting material ".

The aphorism that history repeats itself is evidenced in the governmental attitude towards the provision of vegetable fats. Immediately after the First World War the British Colonial Office apparently begrudged the expenditure of a few hundred thousand pounds for the support of piqui-á plantations and for the establishment of large-scale fat manufacture from the nuts. But in 1947, when a grave shortage of fats was actually in being, the British Government squandered between £30,000,000 and £40,000,000 for the establishment in Tanganyika Territory of plantations of ground-nuts, in order to add materially to Great Britain's meagre supply of edible fats. The attempt to accomplish in three or four years what could not justifiably be expected in less than 20 or 30 years, was a disastrous failure.

We are now back in the position of the 1920's—and have forgotten everything and learnt nothing. Prices of fats have fallen from the shortage period of 1945, supplies are more ample, and interest in developing new sources of supply is at a minimum again. It is amazing that government departments do not appreciate that it requires 25 years or more to develop a new oilseed crop in sufficient quantity to make an appreciable contribution to world supplies. It is at times, like the 'twenties or the present, when there is no pressing shortage that such projects should be put in hand and steadily and actively developed, at first on an experimental farm as a pilot scheme, and finally on full plantation scale. New agricultural crops—especially in the Tropics, in all probability—cannot be established on a large scale in a hurry, like rushing up munition or other factories to cope with the exigencies of war; but this apparently is still not comprehended.

Apart from the satisfaction of the British market, there are much more cogent considerations. It has been estimated that at least two-thirds of mankind suffer from malnutrition—some authorities would put the proportion as high as 85%. Within the next 25 years world food production must be at least doubled if we are to allow for the probable increase of population and at the same time to raise the living standard of the great bulk of mankind to a reasonable level of subsistence. Instead of continuous progress towards this goal, there has even been retrogression. The Second World Food Survey (1952) of the United Nations Food and Agriculture Organisation reported that the number of people without enough food had grown appreciably in recent years because " annual increases in food production are barely keeping pace with increasing population "—indeed, for the world as a whole (excluding the U.S.S.R., for which it is difficult to secure statistics), the supply per person of cereals, sugar and potatoes amounted to only 97% of the pre-War level.

A report submitted to the Ministers of the 17 Colombo Plan countries, meeting at Singapore in October, 1955, revealed that the population of South and South-East Asia was growing by about 8,000,000 per annum—a rate of increase of 1.6% a year. This rate will become even greater with the effects of the improved health services. In sharp contrast, food production for the year 1954–55 was 3% below that of the previous year. In general, the peoples of these areas were eating even less than before the Second World War, and only a succession of good seasons had averted serious and widespread famine.

In the face of these disturbing facts, one wonders how long the nations of the world can afford to neglect the potential output of plantations of such proven commodities as the oils of piqui-á and batiputa.

Sources

Data for this article were derived from:

Records of the Royal Botanic Gardens, Kew.

Private papers of the late Sir Henry Wickham.

Private papers of the late Joseph Cadman.

Department of Agriculture, Kuala Lumpur, Malaya.

Malaya House, 57 Trafalgar Square, London, W.C. 2.

Notes supplied by Professor T. P. Hilditch, of the University of Liverpool. Professor Hilditch is a recognized authority on edible oils and fats. He has put me very much in his debt by reading and approving this article.

IX International Botanical Congress

The Ninth International Botanical Congress will be held in Montreal, Canada, from August 19 to 29, 1959, at McGill University and the University of Montreal. The program will include papers and symposia related to all branches of pure and applied botany. A first circular giving information on program, accommodation, excursions, and other detail will be available early in 1958. This circular and subsequent circulars including application forms will be sent only to those who write to the Secretary-General asking to be placed on the Congress mailing list:

Dr. C. Frankton
Secretary-General
IX International Botanical Congress
Science Service Building
Ottawa, Ontario
Canada

Some Aspects of the Oil Palm in Indonesia

Because of the increasing importance of the oil palm in the agriculture of the East Indies, a study of the variations in vegetative and floral characteristics is important. Some varieties have fruit with greater oil-yielding potential than others, and selections for greater yields must begin with these.

CECIL YAMPOLSKY [1]

The oil palm (*Elaeis guineensis* Jacq.) is indigenous to Africa, and was introduced into the Malay Archipelago as a decorative plant. As such it is today widely distributed in the East Indies. As a cultivated crop it has its widest exploitation on the East Coast of Sumatra. As a companion crop to *Hevea braziliensis* on several rubber estates, it has justified the wisdom of those who uphold diversified agriculture.

The date of its introduction into Indonesia, **1848** (**7**), is of significance because the offspring of the first trees there have maintained a genetic stability.

The increasing importance of the oil palm as a cultivated crop, its adaptability to the conditions in the East Indies, and the yields that have already been secured, mark this plant as an important one in the agriculture of the islands.

The offspring of the seed originally imported into the Indies show a fairly uniform character and they are, in the main, excellent yielders of oil. In subsequent importations from Africa by private concerns, types of fruit have been introduced whose dissemination will ultimately offer a serious handicap to oil production, due to their low yielding qualities. The variability within the species is of considerable interest, not only to the practical grower but also to the botanist.

The Dutch Government, in its desire to introduce the most suitable forms, has collected from Africa an extensive number of varieties which have been grown to determine their value as oil producers. The Cultuurtuin of Buitenzorg contains many mature trees from those importations. The experimental garden at Bogor Redjo, Sumatra, has an equally valuable collection. The two "diwakawaka" trees on the Balong Estate in Djapara make the collections in Java and Sumatra complete. With the collections as a basis, study of the forms as they are known was greatly facilitated and evaluation of them made possible.

Inflorescence

The oil palm is monoecious, separate male and female inflorescences being borne in the axils of the leaves. Whereas monoecism is the rule, there are trees that show one kind of inflorescence to the complete exclusion of the other. The stability of such dioecious forms has not been tested, nor do we find in the literature observations which lead to the justification of a form alluded to as "dioica" (4). Female inflorescences with a male branch, male inflorescences with a female branch, or inflorescences that are half female and half male are not uncommon. Some trees, without showing any loss in vegetative vigor, may fail to produce any kind of inflorescence. The various types of inflorescence are pictured in Fig. 3.

The so-called inter-sexualism of the inflorescence is a very common phenomenon in young plants, but occurs spor-

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adically in plants of all ages. The sex tendencies of a given oil palm, when traced from the young stage to the mature stage, suggest a cyclic change in sex. The first inflorescences are as a rule male; then follow the female inflorescences, giving the monoecious character to the tree. The total number of both male and female inflorescences is


FIG. 1. Oil-palm trees under cultivation, Sumatra. (Courtesy of G. F. J. Bley, Buitenzorg, Java)

dependent on the number of leaves that are produced, since one inflorescence arises in the axil of each leaf. The ratio of male and female inflorescences at a given time for several trees of the same age varies greatly.

Varietal Differences

Varietal differences in oil palms were recognized by the Africans before the Europeans exploited the plant for commercial purposes. Detection of the fine differences among the palms shows a keen diagnostic sense on their part.

The systematic value of the forms has been the subject of a voluminous literature. Whereas in the main, the tendency has been to include all oil palms under *Elaeis guineensis*, a most radical departure has been that of Annet (1) who has raised to specific rank the form of fruit with accessory sterile carpels, " diwakawaka " of Bücher and Fickendey. The character of the individual fruit has been commonly taken as the basis for the establishment of horticultural varieties. Only in a lesser degree have other characters of the tree been considered. In the individual fruit the following distinguishing features have been used: color before and after ripening; form: long,

FIG. 2. Oil palm in bearing. Fruits in various stages of development. The male inflorescences: the one to the left withered, the other shedding pollen. (Courtesy of G. F. J Bley, Buitenzorg, Java)

short, compressed; thickness of shell; absence of shell; presence of accessory sterile carpels.

Gross Structure of the Fruit

Becarri (2) has ably discussed the structure of the flower and the inflorescence as a whole. Rutgers (9) has more recently completed a more detailed study on the origin and development of the inflorescence. The fruit may be roughly divided into three elements, namely, pericarp (epi- and mesocarp), shell (endocarp) and kernel (endosperm), in which the embryo lies (Fig. 4). The pericarp, which yields the commercial palm oil, is orange yellow at maturity. It is the most perishable part of the fruit; soon after ripening it undergoes fermentation. If this process is not checked, free fatty acids are formed. The color of the pericarp is normally masked by the pigment in the sub-epidermal layer. At maturity the cells of the pericarp are filled with fat globules.

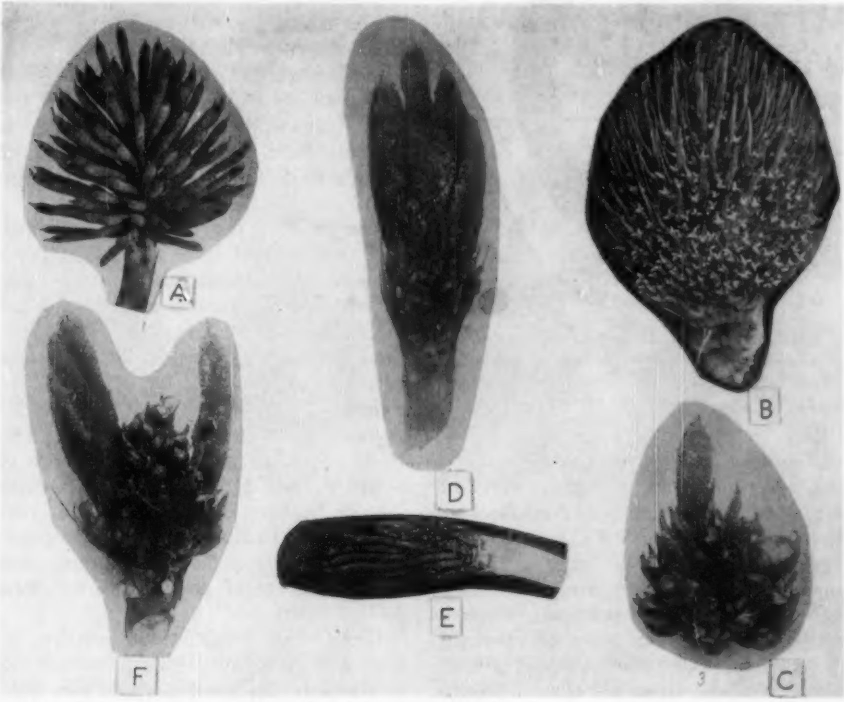

FIG. 3. Inflorescence types. A. Male inflorence (Photograph Dr. C. Heusser). B. Female inflorescence (Photograph Dr. C. Heusser). C. Female inflorescence with one male branch (Photograph Dep't. Landbouw). D. Male inflorescence with one female branch (Photograph Dep't. Landbouw). E. Male inflorescence with several female branches. F. Inflorescence half male, half female (Photograph Dep't. Landbouw).

Bruising of fruits in the field during harvesting, as well as delayed processing of the oil, result in a very high percent of free fatty acids. This is of great significance in the estate preparation of oil and has resulted in established procedures in the field and in the factory (9).

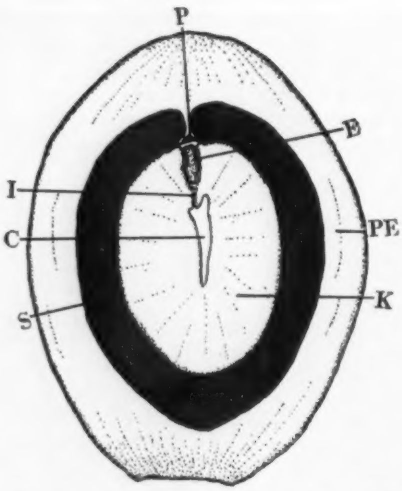

FIG. 4. Longitudinal section of fruit of *E. guineensis*. E—embryo, K—kernel, S—shell, PE—pericarp, P—plug, C—cavity in kernel (endosperm), I—canal of intercommunication between cavity in which embryo lies. ×2½.

The shell, which for the grower is a waste product, is a highly resistant structure that surrounds and encloses the kernel and the embryo. Communication between the kernel, the embryo and the outside is maintained through openings in the shell. These openings, three in number, can be seen when the pericarp is removed. Only one, however, is functional. Where there are three embryos, all are functional. In rare cases there are four embryos with four or more openings in the shell. Shells with six openings have also been reported.

The kernel, which yields the commercial kernel oil, is white. It is of a cheesy consistency before ripening of the fruit, and after losing water it takes on a horny consistency. The shape of the kernel conforms in general to that of the whole nut. Fruits from the interior parts of heads are more compressed and angular, so the kernel, too, is often angular. The shapes that kernels may assume can be seen in the accompanying figure (Fig. 5). The cavity in the center is present in all kernels. In cross section it is, as a rule, triangular; in longitudinal section, it is elongated and spindle-shaped. This cavity is homologous with the conspicuous " milk " cavity of the coconut; it communicates with the one in which the embryo lies by a tiny canal shown in Fig. 4.

During germination, the haustorium of the embryo digests its way into the kernel (endosperm), leaving nothing but the cork zone. This has been described in greater detail in another publication (12).

The relative proportions of pericarp, shell and kernel have served in great measure as diagnostic characters for varieties. These elements of the fruits are highly variable. Even within a fruit head (Figs. 8, 9) considerable variation occurs. In tree No. 60, St. Cyr, the weight of fruit varied from 8.5 to 31.25 grams; the weight of pericarp, from 4.45 to 16.35 grams; and the percentage of pericarp, from 41 to 71 percent. In tree No. 19, St. Cyr, the weight of fruit varied from 8.5 to 20.7 grams; the weight of the pericarp, from 5.5 to 13.1 grams; and the percentage of pericarp varied from 50 to 70 percent.

Cross and longitudinal sections of fruit present a fairly good picture of the relations of the gross parts of the fruit. Classification on the basis of thickness of shell or thickness of pericarp is obviously inaccurate, since shell and pericarp are not of equal thickness throughout. From the many types of fruit, an intergrading series with the very thick-shelled as one extreme and the shelless form at the other end can be fashioned. From results discussed later, the three following types tend to show genetic stability: thick-shelled seed with thin pericarp; medium-shelled fruit with medium pericarp; thin-shelled fruit with medium pericarp. The differences be-

tween the three forms are in the proportions of the pericarp (epi- and mesocarp), shell (endocarp) and kernel.

Thick-Shelled Form with Thin Pericarp. In Fig. 6, A & B, cross and longitudinal sections of a thick-shelled form are shown. The shell, in contrast to the rest of the fruit, occupies the largest volume. The pericarp, which yields the pericarp oil, is very much reduced. The kernel, too, is reduced in size, and consequently the yield in kernel oil is smaller.

This form with thin pericarp and thick shell is widely distributed among the estates in Sumatra, where in one case at least, over 15 percent of the trees are of that type and consequently are worthless from the commercial point of view.

Measurements on a mixed lot of 24 trees by Mr. Stuit, Administrateur of the Gouverenements Proef-en Zaadtuin, Bogar Redjo, Sumatra, and placed at my disposal by Dr. I. Boldingh, give a rough idea of the variations in the elements that make up the fruits: pericarp, 2–5 mm.; thickness of shell, 1–5 mm.; diameter of kernel, 6.5–12 mm. Among them are individuals with thin pericarp and thick shells.

On the East Coast of Sumatra, where similar measurements were taken, fruits showed a range of 0.75 to 2.5 mm. for pericarp and 4.0 to 8.5 mm. for shell thickness. The extreme figure for shell thickness is higher than that given by the several authors on the African thick-shelled forms.

Thin pericarp is not always associated with thick shell. Thus in a type shown in Fig. 7 B, although the pericarp is very thin, the shell belongs to the medium form.

Bücher and Fickendey (3) estimate that the percent of pericarp in the thick-shelled forms varies from 30 to 40 percent. They include under their classification also the medium-shelled form which from all available data appears to be constant. In Sumatra the data show the percent of pericarp in a thick-shelled form to reach a high of 30 percent.

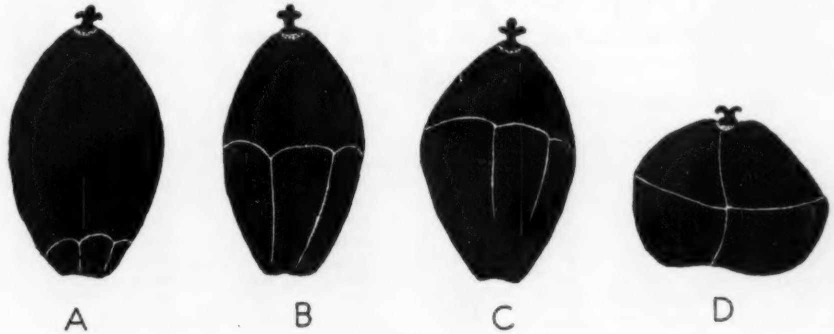

FIG. 5. Fruit shapes from various positions on inflorescence. A. Fruit from periphery. B. Fruit deeper in head. C. Fruit still deeper in head. D. Fruit from innermost part of head.

This thick-shelled form is known among the planters of the East Coast of Sumatra as the "Congo" type. The estates that have secured seed of unknown ancestry have a large percentage of undesirable trees of this type.

Attempts have been made to correlate the character of the petiole of the leaf (usually a narrow, long, petiole) with thick shell. This, however, has so far yielded negative results. An examination of hundreds of plants in the field gave no definite evidence. The influ-

ence of soil, climate and moisture on such forms is still unknown and it is impossible to say to what degree variation in thickness and in size of pericarp is attributable to external factors.

Medium-Shelled Form with Medium Pericarp. Fig. 6, C & D, reveal cross and longitudinal sections of fruit with medium thick pericarp and shell. The reduction in thickness of the shell and the increase in thickness of the pericarp make this form more desirable. Here again measurements of pericarp and shell thickness give no true value of the fruits.

Most of the ornamental trees and estate trees of Sumatra, which originated from the St. Cyr trees and their offspring, show a high degree of uniformity. To be sure, there have been importations from Africa, and from Buitenzorg, Java. The oldest trees in Buitenzorg are of the same type as those in St. Cyr. The offspring from these trees observed in Sumatra and in Java maintain the character of the mother trees.

The following table, taken from Rutgers (8) and calculated on the basis of relative weight of head and fruit where

TABLE I

WEIGHT OF HEADS, PERICARP, NUTS AND KERNELS IN PERCENT OF THE WHOLE FRUIT

Location and age of trees		No. of fruits from head examined	Fruit	Pericarp	Nuts	Kernel (% of nut)
		East Coast of Sumatra				
Mata Pao Plantation trees	5 yrs.	270	100%	60%	40%	7%
Poeloe Radja Plantation trees	7 "	310	100%	63%	37%	7%
St. Cyr (Avenue trees) H	7 "	200	100%	64%	36%	8%
St. Cyr (Avenue trees) E	15 "	220	100%	65%	35%	7%
St. Cyr (Avenue trees) B	20 "	200	100%	55%	45%	11%
Bekalla Plantation trees	20 "	255	100%	65%	35%	8%
Bekalla (Avenue trees)	30 "	215	100%	62%	38%	9%
St. Cyr (Avenue trees) A	34 "	280	100%	63%	37%	8%
		Buitenzorg, Java				
Selection garden, Buitenzorg, 1916 and 1917 (van Helten	40 "	200	100%	54%	46%	16%
		Africa				
Chevalier	1910	150	100%	40%	60%	20%
Adam	1910	125	100%	43%	57%	20%
Hubert	1911	150	100%	44%	66%	20%
Janssens	1917	175	100%	38%	62%	11%
Janssens	1917	150	100%	63%	37%	10%
Average		150	100%	45%	55%	10%

This medium-shelled form with medium pericarp is widely distributed over the East Coast of Sumatra. According to Rutgers (8), the St. Cyr estate trees planted in 1884 came from the Botanical Gardens of Singapore. The trees of the Bekalla Estate (1888) and the Tandjong Morawa Estate (1903) originated from the avenue trees of St. Cyr. In this instance three distinct generations can be studied and compared.

the fruit is regarded as 100, shows a striking constancy in this form.

The almost uniform agreement in the Sumatra type is very apparent. It is also to be borne in mind that the trees of the St. Cyr group—B (20 years), E (15 years) and H (7 years)—as well as those of Bekalla (20 years) are either direct offspring or descendants from offspring of St. Cyr A (34 years old). The trees of Mata Pao and Poeloe Radja, ex-

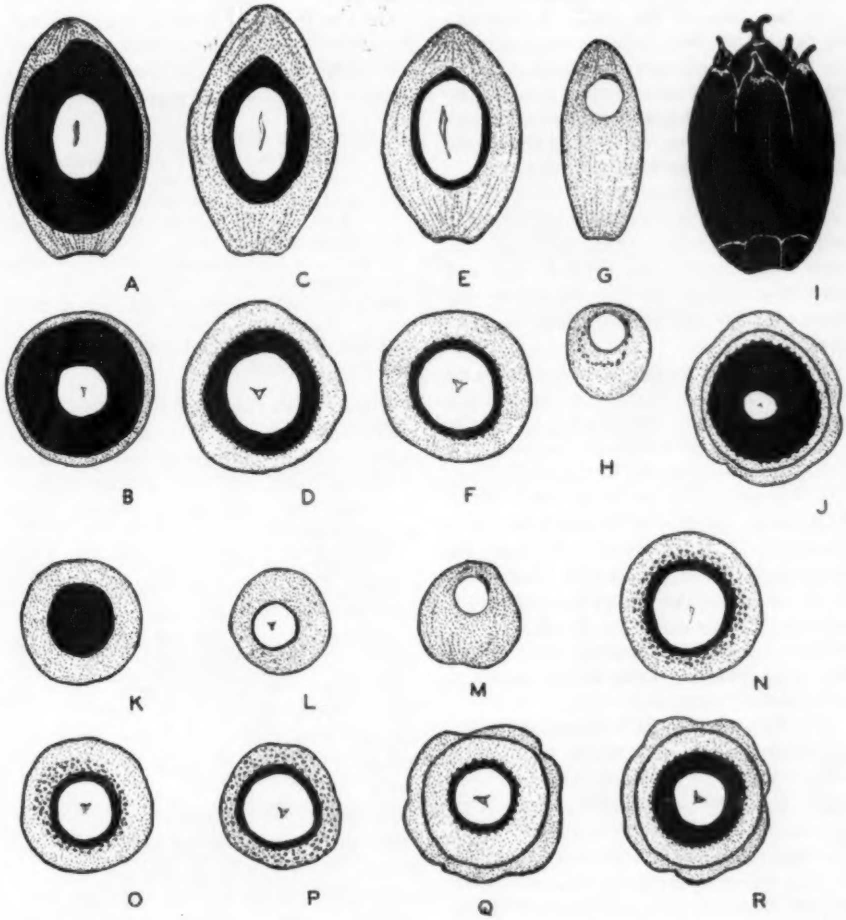

FIG. 6. Cross and longitudinal sections of recognized varieties. A. Longitudinal section, thick-shelled form (dura). B. Cross section, thick-shelled form. C. Longitudinal section, medium-shelled form (semi dura). D. Cross section, medium-shelled form. E. Longitudinal section, thin-shelled form (tenera). F. Cross section, thin-shelled form. G. Longitudinal section, shell-less form (long form). H. Cross section, shell-less form. I. Diwakawaka fruit. J. Cross section, thick-shelled " diwakawaka " fruit. K. Cross section, parthenocarpic fruit. L. Cross section, very thin-shelled fruit. M. Longitudinal section, shell-less fruit (squat form). N. Cross section, thin-shelled form with zone of fibers. O. Cross section, thin-shelled form with zone of fibers. P. Cross section, thin-shelled form with fibers scattered through pericarp. Q. Cross section, thin-shelled " diwakawaka " form. R. Cross section, medium-shelled " diwakawaka " form.

cept for some importations from Africa, are offspring from St. Cyr trees.

In the data on the trees of Sumatra we have the first reliable evidence on the constancy of a given type of oil palm fruit. This is commonly known as the " Deli type ". It agrees in general structure with the trees of Buitenzorg whose introduction dates back to 1848.

The lower percentage of pericarp of the trees of Buitenzorg, Van Helten (11) ascribes to the fact that, although the trees were planted in 1878, it was not until the recent interest in oil palms arose that the soil around them was cultivated.

Thin-Shelled Type. Longitudinal and cross sections of this type, commonly called " Lisombe ", are shown in Fig. 6, E & F. The outstanding characteristic is a thin shell, varying in thickness from 1 to 2.5 mm. The pericarp forms 60 to 80 percent of the fruit. Bücher and Fickendey give 60 percent pericarp, 20 percent shell and 20 percent kernel. J. G. J. A. Maas, Agriculturist of the Algemeen Proefstation A. V. R. O. S., Medan, Sumatra, reports a tree on the East Coast of Sumatra, with a pericarp yield of 82.5 percent.

The thin-shelled fruit shows variation in thickness of pericarp as well as in size of kernel. In fruits with medium thick pericarp, thin shell and large kernel, the percent of pericarp is no greater than in the medium-shelled type. In this thin-shelled type, however, with greatly reduced nut, the percentage of pericarp runs as high as 80 (Fig. 6 L). Fig. 6, N, O, P, shows cross sections of types of thin-shelled fruits with brown fibers scattered in the pericarp, thus reducing considerably the oil-bearing property of the pericarp. A fruit like the one in Fig. 6 P, is as undesirable as a thick-shelled form.

Whereas the genetic constancy of the thin-shelled type is not definitely determined, the evidence at hand indicates that this form possesses a great degree of stability.

On the Bangoen Estate, near Siantar, Sumatra, a small planting of trees from " Lisombe " seed secured from the Congo showed the following types:

28 trees—thin shelled
These trees showed great variation in size of fruit; in thickness of pericarp; and in size of the nuts, ranging from twice the size of a pea to those with a diameter of 2.5 mm.
34 trees—thin pericarp and thick shell (Congo type)
8 trees—medium pericarp and medium shell (Deli type)
2 trees—pisifera or shell-less
4 trees—no fruit set

A total of 76 trees yielded 28 distinctly thin-shelled fruits. It must be emphasized that self-pollination rarely occurs in the oil palm, and seed, unless pollination has been controlled, results from cross-pollination.

Through the efforts of Dr. P. J. S. Cramer, Director of the Experiment Station, Buitenzorg, and former chief of the Selection Division, all the known varieties were introduced into the experimental gardens in Java and Sumatra. These importations have been of the highest significance in determining the values of the forms as cultivated in Indonesia.

In order to determine the genetic stability of the thin-shelled imports, Bogor Redja was selected as the site for experiments. Seven lots of seed, all thin-shelled, were planted under similar conditions and given the same treatment. The trees were examined when mature by sampling fruits from various parts of the fruit-heads to determine shell thickness. No attempt was made at this time to ascertain the variability in shell thickness of the trees not accepted as thin-shelled, nor was any attempt made to give a genetic interpretation to the data.

Seven lots of seed were planted; the mature trees showed the following:

In Block XII (Bogor Redjo) N'Sombo M—25 trees showed	10 thin-shelled 15 medium- and thick-shelled
N'Sombo N—19 " "	8 thin-shelled 11 medium- and thick-shelled
N'Sombo O—25 " "	11 thin-shelled 14 medium- and thick-shelled
N'Sombo H—23 " "	14 thin-shelled 9 medium- and thick-shelled
Total 92 trees	43 thin-shelled 49 medium- and thick-shelled
In Block XXVIII (Congo Import) 50 trees showed	19 thin-shelled 31 medium- and thick-shelled
In Block XXVII (Congo Import) N'Sombo L—50 trees showed	31 thin-shelled 19 medium- and thick-shelled
In Block XXIX (Congo Import) Lisombe—25 trees showed	1 thin-shelled 24 medium- and thick-shelled
Grand total 215 trees showed	94 thin-shelled 123 medium- and thick-shelled

Among all three forms, variations occurred. In only one case (1 thin- and 24 medium- and thick-shelled) was there an overwhelming preponderance of the other type.

Not until selfed seed of Lisombe is tested, can the stability of that form be determined. The breeding results do point, however, to a type that gives indications of stability, and one is justified in assuming that the thin-shelled form, like Congo and Deli, is genetically more or less constant.

Parthenocarpic Fruits. A not uncommon type is the so-called parthenocarpic fruit, characterized by an absence of embryo and endosperm and by a reduced pit, solid throughout (Fig. 6 K). It may sometimes reach the size of normal fruit, its pericarp is rich in oil, and in the pit, stone and bast cells occupy the space normally occupied by endosperm and embryo. Whether this fruit is truly parthenocarpic or is the result of fertilization followed by abortion, allowing the developing shell to push into the endosperm cavity, has not been determined. In making sections through the solid pits, traces of the three plugs (opercula) marking the position of the three ovules are found.

Shell-less, or Pisifera, Type. This fruit is characteriezd by an absence of a shell and by its small size. Fig. 6, F, H, & M, show longitudinal and cross sections. In contrast with the other fruits it displays a marked reduction in all dimensions. Fruits examined in Sumatra and Java weighed from 4 to 6.5 grams. Surrounding the endosperm is a layer of cork cells typical of all oil-palm kernels. The conical structure is the plug which on germination in the shelled forms is pushed through the germ pore (Fig. 4). I have described elsewhere in detail the structure of the fruits of *Elaeis* (12). This form occurs but rarely; De Briey (5) calculates 1 in 50,000. At Bangoon, Sumatra, among several hundred palms, there were three pisifera specimens. In Java the only one under observation is in the Cultuurtuin at Buitenzorg.

Fruits analyzed in Sumatra yielded 99 percent pericarp flesh. The oil content in individuals from the same head varied from 55 to 59 percent.

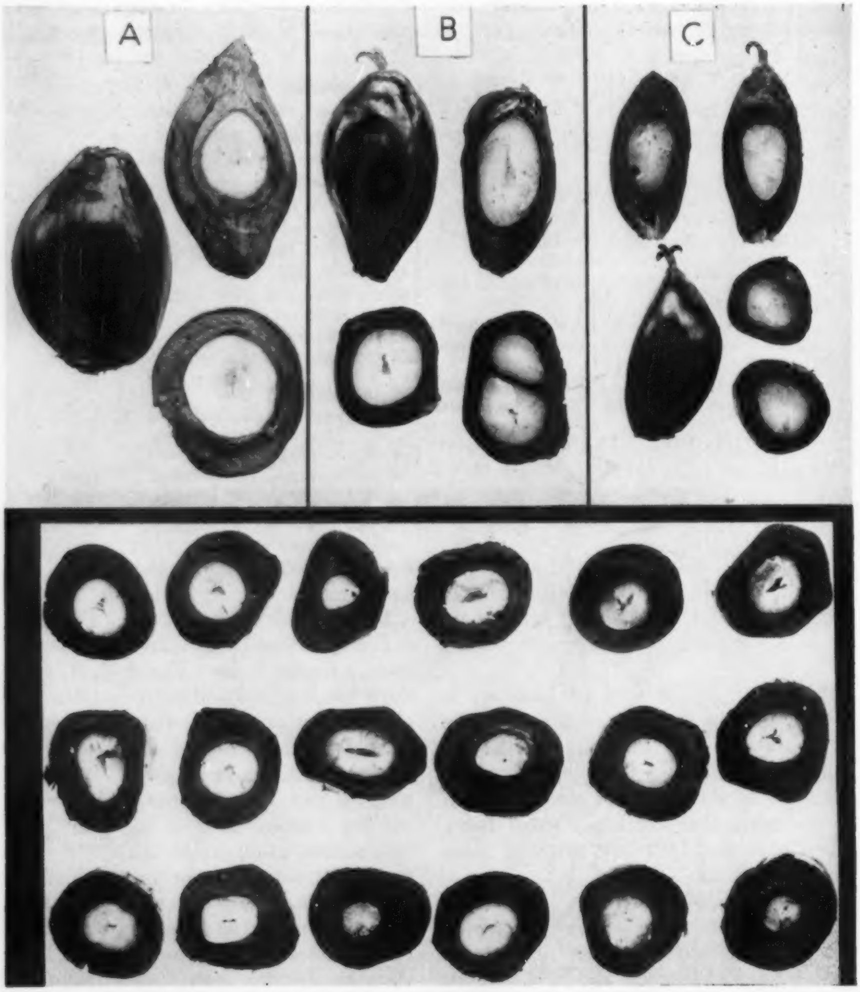

FIG. 7. A. Large, thin-shelled fruit with large kernel and medium pericarp. B. Medium, thin-shelled fruit with medium kernel and thin pericarp. C. Small, medium-shelled fruit with thin pericarp.

FIG. 8. Thin-shelled fruits in cross sectional view showing variations in size of elements. Fruits from the same head.

In another publication it was suggested that the pisifera is most likely a pathological form (12), an opinion previously expressed by Beccari (2). Fruit heads from a pisifera tree and a Lisombe tree, where only a few typical fruits were set, were examined and contrasted. The undeveloped fruits on the Lisombe head were identical with the fruit of the pisifera head. By making longitudinal and

cross sections of fruits from both trees, homologous structures in both were found to be alike.

The embryo appears to be normal as far as structure is concerned. The kernel or endosperm is small, and even if the embryo were capable of resuming growth, it is doubtful that there would

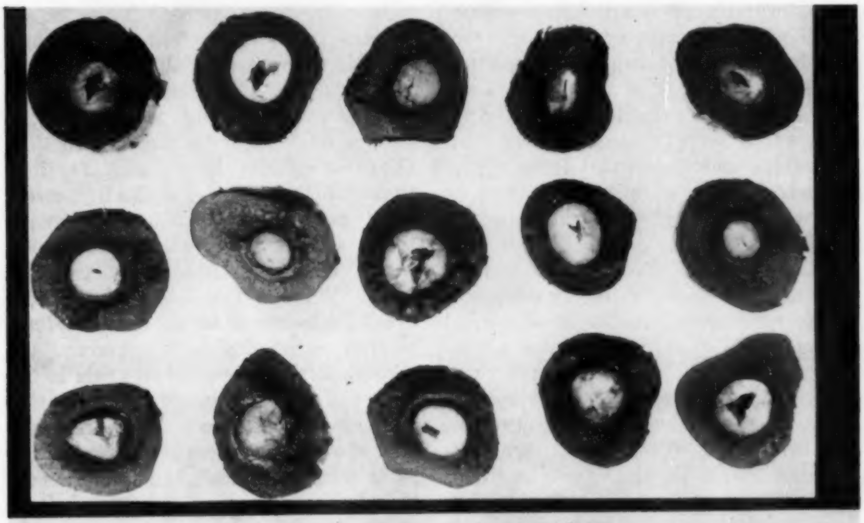

FIG. 9. Thin-shelled fruits in cross sectional view showing variations in size of elements. Fruits from same head.

FIG. 10. Fruits from " diwakawaka " showing variations in mantle. Also cross and longitudinal sections. Fruits from the same head.

be sufficient nourishment in the endosperm to tide it over until it could be independent. On the basis of observations, the so-called pisifera form is not to be considered a normal variant of the oil palm; rather, it is a pathological form in which some factor or factors prevent the development of a shell, as a result of which, the whole fruit remains dwarfed and incompletely developed.

It would be interesting to keep pisifera trees under observation for longer periods under controlled conditions to see whether fruits with shells could be produced.

"Diwakawaka" Form. This form is characterized by an accessory mantle of tissue surrounding the fruit of normal structure. The mantle contains a considerable amount of pericarp oil. Fig. 6, I, J, Q, & R, show external appearance, longitudinal and cross sections of the fruits. Fig. 6, J, Q, & R, are cross sections of thick-, thin-, and medium-shelled forms. The longitudinal section is shown in Fig. 10. These fruits occur in three forms, based on shell thickness. The accessory mantle results from a coalescing of six or more accessory sterile carpels. In Java there are only three such trees, one in Buitenzorg in the Cultuurtuin, the other two on the Balong Estate in Djapara. These three trees, however, represent the three types of shell thickness described for the normal forms.

The Germans in South Africa recognized the value of this form and began experiments with it. Unfortunately the investigations were not completed. Gruner (6) has given some data on the form. Bücher and Fickendey (3) give the following proportions for the thin-shelled "Diwakawaka" form (*Elaeis g.* var. *diwakawaka*):

Mantle flesh	50	percent
Pericarp "	34.5	percent
Shell	11	percent
Kernel	4.5	percent

The stability of such a form is not established. Gruner (11) reports that from 61 seedlings, 51 were Klode (diwakawaka) and ten were of the ordinary form. No mention is made of the thickness of pericarp and shell in the 51 plants. The evidence from Java is more meager. Of two trees labelled "diwakawaka" in the Cultuurtuin in Buitenzorg, one was a thick-shelled diwakawaka, the other a thick-shelled ordinary form. In Djapara on the Balong Estate, four trees labelled "diwakawaka" showed, upon examination, two good Lisombe types and two "diwakawaka" types, one a medium-shelled "diwakawaka" form. Whether the so-called "doubleness", represented by the mantled form of fruit, is inheritable, is unknown. On a single head there are variations in the degree of doubling among the fruits. In the tree in Buitenzorg there are fruits that show no accessory parts, and in the same head are fruits completely surrounded by a mantle consisting of six or more fused accessory sterile carpels. From such fruits there is a graded series of mantle development, ranging from absence of mantle, some with just an indication of a mantle in the form of a thickened oil-bearing scale, and so on increasing to a complete mantle. This is shown in Fig. 10. Often the mantle, in the form of a cup, extends only a short distance up from the base of the fruit, and then again it may extend half way up or higher. The fruits in Fig. 10 were taken from various parts of the same fruit head.

Annet (1) has raised this form to specific rank, and in one of his publications proposes the name *Elaeis Poissoni* for the tree with mantled fruit. Stability of this fruit has not been substantiated by breeding experiments. If such characters are to be accepted as diagnostic for a species, then all teratological forms of plants, and these are legion, must also be lifted to specific rank.

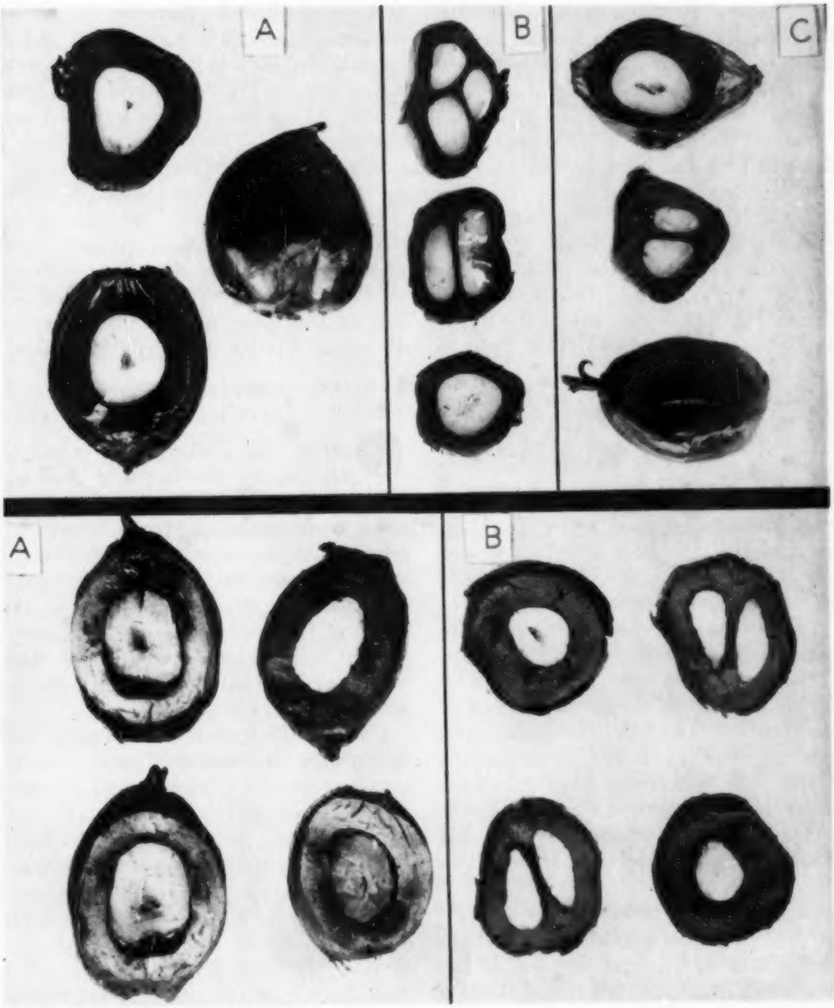

FIG. 11. A. Deli type fruit with somewhat thin pericarp. B. Cross section of fruits from the same herd with 1, 2 and 3 kernels. C. Medium-shelled fruit with thin pericarp taken from same tree as Fig. 12 A.

FIG. 12. A. Fruits from heads where only few fruits were set (contrast Fig. 11 A). B. Fruits with thick shell and thin pericarp (Congo type, var. dura).

Factors Influencing Form of Fruit. There are many external factors which influence the size, the shape and the color of the fruit, both internally and externally. From the very structure of the female inflorescence, it is to be expected that the fruits towards the inside of the head, as a result of mutual pressure exerted by the hundreds of developing fruits, will be modified. Fruits from

the innermost part of a head are angular. They are, as a rule, smaller and shorter than those near or at the periphery of the head. The figures in Fig. 5 are from the same fruit head. Fig. 5 A represents a fruit at the periphery. Pressure from adjacent fruit has been exerted near the base and the depressed areas show the extent of the pressure. Fig. 5 B represents a fruit somewhat deeper set in the head, the angular faces reaching half way up. Fig. 5 C is of a fruit still deeper in, and Fig. 5 D depicts one in the innermost part of the head. That fruit is quite angular and squat. It is conceivable that investigators who have had access to individual fruits and not whole heads might accept such fruits as distinct forms.

Elaeis guineensis var. *angulos* Becarri is no doubt based upon fruits that show angularity of the kind described above, and it is therefore doubtful that such characters have diagnostic value.

The presence of two or more endosperms within a nut modifies the shape of the nut and in turn the fruit. This can be seen from the cross sections of the fruits with two and three endosperms showing (Figs. 7, 11, 12). The position of the fruit within the head influences the intensity of pigmentation at ripening. A type of fruit represented by Fig. 5 D is always of a lighter orange red than Figs. 5 A, B, or C.

The number of fruits set in a head, which is largely a degree of pollination, may influence the shape and size of the individual fruits. Fruits in well filled heads will be more angular. In poorly set heads the fruits will be rounded and larger. This is due to the absence of mutual pressure and probably to a more ample supply of food.

Fruits from the same tree but from different heads may vary greatly. Fig. 12 A shows sections through fruits of large dimensions from a head where only a few fruits had been set. These fruits agree with the descriptions of the large and thick-shelled varieties of other writers. The shell is 8 mm. thick and in longitudinal section the kernel is 16 mm. Specimens for Fig. 11 A were taken from a head on the same tree where seed was uniformly set. They are considerably smaller. Each group represents the largest individuals from the respective heads.

Here again it must be emphasized that a classification based merely upon observations in the field, unsubstantiated by experimental data, is unreliable due to the great amount of variation, obviously a result of external conditions.

Variations in the Elements of a Fruit

Attention has already been called to the variation in the fruits of a single fruit-head. Figs. 8 and 9 show cross sections of thin-shelled fruits from two trees. In cross-section there are circular outlines, oval outlines and polygonal outlines, suggesting the position of the fruits in the fruit-heads, the least compressed being the outermost. The fruits vary greatly in the thickness of pericarp and in diameter of shells.

Color of the fruit before maturity and at ripening has been used as a diagnostic character by Chevalier (4), Beccari (2), Bücher and Fickendey (3) and others. Trees with light green fruits which at maturity turn a bright orange; trees with fruits that are almost black at maturity; white fruits; green fruits with thick shell; green fruits with thin shell; "diwakawaka" form of green fruit have been described. Examples of all but the albino and the green "diwakawaka" have been studied in Sumatra and Java.

Gruner (6) described a "Klode" (diwakawaka) where the individual fruits at the apex of the head were green above and brick red at the base. The rest of the head was brick red. Mature fruit heads in the Cultuurtuin at Buitenzorg were bright green at the apex, purple black at the base. This sectorial ar-

rangement, while not very common, is not rare.

From a botanical point of view the diagnostic value of a form cannot be entirely based on small differences in fruit. In any population of palms, variations occur in all parts of the plants. These variations manifest themselves in the size of the trees, trunk circumference, the spiral of the leaf bases (left or right spiral), drooping leaf, upright leaf, broad leaf base, narrow leaf base, differences in pigmentation of the leaf petiole, fruit heads with large coarse spines, fruit head with short spines.

So far, only the following three, because of their genetic stability, merit varietal recognition:

Elaeis guineensis Jacq.
var. *dura* Becc. (Congo type)
var. *semi dura* Becc. (Deli type)
var. *tenera* Becc. (Lisombe type)

All other forms recognized by the several authors fall into one of the three varieties. Only after their stability has been established can they be given varietal rank.

Selection

Selection for high yield of oil has been undertaken by the Indonesian Department of Agriculture through the introduction of all known varieties by the Algemeene Proefstation der A.V.R.O.S., Sumatra, and also by many private estates in Sumatra. The Deli type grown in Sumatra is excellent because of its large fruit heads and high yields of oil. The selectionist, however, is concerned in establishing types with still better production of oil.

Any one of the three parts of the fruit—pericarp, shell, and kernel—is modifiable, and variation in the relative size of it might become stabilized through selection and breeding. Assuming that the aim is to increase production of the pericarp oil, how is one to proceed to obtain this through selection?

We may conceive, for the sake of clarity, that in the individual fruit we are dealing with a series of three concentric circles: the outer, the pericarp; the middle, the shell; and the innermost, the kernel. In such a series, increase in the outermost, having the greatest circumference, will result in a greater increase in volume than a corresponding decrease in the circumference of the second circle. In other words, an increase in circumference of the pericarp will yield more oil tissue than a corresponding decrease in the size of the nut. Furthermore, with the establishment of regular agricultural practice, a demand for more uniform kernels will develop. The nuts sent whole from Africa to several European ports have represented at best a very heterogeneous collection—small, medium and large kernels. Therefore, one objective of selection is to obtain fruits with large pericarp, thin shell and large kernel.

In addition, however, the entire fruitheads must also be considered, for they vary in size and number. The size is dependent upon the size and number of fruits in it. Rutgers' (9) report of a head, the result of artificial pollination, that weighed 78 kg. and contained 4400 individual fruits, is striking. Rutgers (8), in Table 1, gives the average for Africa as 6 kg.; for Java, 19 kg.; for young trees in Sumatra, 4.6 kg.; and for older trees in Sumatra, 19 kg. The size of heads varies with age, that of heads on young trees always being smaller.

The number of heads per year produced on a tree is also variable, for some trees tend to produce larger numbers of female inflorescences than do others.

The medium thick-shelled type (Deli) is the most productive at present, primarily because of its uniformity, but the thin-shelled type may ultimately outyield it as a result of selection. There are individual Lisombe trees in Buitenzorg and in Sumatra whose individual

fruits compare favorably with the large fruits of the Deli type.

It is the total yield that is important. The 99 percent pericarp of the pisifera, with fruits averaging a little over six grams as the extreme, is surely not so desirable as fruit of 31 grams, of which 60 percent is pericarp.

An ideal tree would be one with many large heads containing many large fruits with a high percentage of pericarp and also high percent of oil. Fruits vary also in the percent of oil contained in the pericarp (**8**, Table XVII) and there can be no doubt that individual variations in this characteristic must play an important role in selection.

Summary

The oil palm, grown extensively as a companion crop to *Hevea braziliensis* in the East Indies, has justified its exploitation. The "Deli" type, the first introduced, is one of the best varieties for oil-yield. Subsequent varietal introductions show great variability in oil production.

The relative proportions of pericarp, which yields the palm oil, the shell, a waste product, and the kernel, which yields kernel oil, determine the economic value of the variety. The size, shape, and percentage of the fruit parts are used as diagnostic characters in the study of the variability of the oil palm. Three types demonstrate genetic stability: thick-shelled with thin pericarp, medium shelled with medium pericarp, and thin-shelled with medium pericarp. On this basis, the following varieties merit botanical recognition:

Elaeis guineensis Jacq.
- var. *dura* Becc. (Congo type), thick-shelled
- var. *semi-dura* Becc. (Deli type), medium-shelled
- var. *tenera* Becc. (Lisombe type), thin-shelled

"Pisifera", a small fruit with shell absent, is apparently sterile. It is, however, on the basis of percentage of oil-yield per fruit, the highest yielder. The "Diwakawaka" form has an accessory mantle of tissue surrounding the normal fruit, a feature of importance because of the additional oil-yielding tissue. The genetic stability of this form is questionable.

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Stem Bromelain—*A New Protease Preparation from Pineapple Plants*[1]

The proteolytic enzymes in this plant product, not yet in commercial production, may find application, as do similar agents from other sources, in the bating of hides, tenderizing of meat, chill-proofing of beer and other directions suggested in this article.

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Introduction

Proteolytic enzymes are tools which have been used in medicine and industry for hundreds of years (7). However, in recent years the commercial uses of proteases have increased and will probably continue to increase as standard, active enzyme preparations with good solubility, stability and odor become available. For this reason the preparation of a new protease mixture from the pineapple plant is an important event which can benefit both industry and medicine.

The early use of proteolytic enzymes was largely empirical. Rarely did the processors realize that proteolytic enzymes were involved in the arts which they practiced. An excellent example of the unwitting use of proteases is the bating of hides, a many century-old craft, in which raw hides are soaked in lime pits to plump the leather, make it softer, and to render it more permeable to tanning agents. An old, seasoned lime pit teems with organisms liberating proteolytic enzymes. These enzymes are largely responsible for the bating action. Even today hide baters follow the ancient custom of adding dog dung to a lime pit to provide an inoculation of protease-producing bacteria. Using standardized proteolytic enzymes is the modern method of achieving bating of hides under controlled conditions and with less offensive odors.

Meat has always been tenderized by proteolytic enzymes. Hanging a tough carcass of venison for a week permits the natural proteolytic enzymes, the cathepsins, which are in every cell, to soften the meat. Hanging it still longer allows molds to grow and produce beneficial proteolytic enzymes which tenderize the meat to the point where gourmets are willing to pay double for what is left of the meat. Proper use of proteolytic enzymes might replace these molds and might retain more of the original weight of the meat. Since World War II home meat tenderizers, sprinkled onto the meat with salt, have become very popular (9).

The largest use for plant proteolytic enzymes is in "chill-proofing" beer. Proteolytic enzymes, when added to beer in the final holding step, hydrolyze certain protein-tannin complexes. If left in beer these complexes become insoluble and form a haze when beer is chilled. The ideal enzyme for this operation is one which will hydrolyze the protein to polypeptides without completing the hydrolysis to small peptides and amino

[1] Published with the approval of the Director as Technical Paper 243 of the Pineapple Research Institute of Hawaii.

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acids. The polypeptides are necessary for flavor and especially for foam retention, a desirable feature of a good beer.

Proteolytic enzymes have other specialty applications. The paint industry (10) has tested proteolytic enzymes for improving the stability of the protein emulsifiers used in latex paints. The processors of egg products use proteolytic enzymes to reduce the viscosity of egg whites before spray drying the white and to partially digest egg yolks so that they may be frozen without gelling (8). Some dairies use pancreatin to stabilize milk against oxidized flavors (1).

Proteolytic enzymes have many interesting applications in medicine. Many inhabitants of tropical countries use plant proteases, such as fig latex, papaya latex and pineapple juice, to digest round worms (6). They also apply plant proteases to suppurating wounds, a technique which is used today in many hospitals. Several medical research groups are studying the effect of proteolytic enzymes on scar tissue. Removing scar tissue before a skin grafting operation is a painful experience for the patient and a tedious and bloody operation for the surgeon. If scar tissue could be debrided enzymatically, the technique would be a major advance in treating people who have extensive third degree burns. Crystalline trypsin is now being injected into the blood stream to dissolve blood clots (11). It may also reduce inflammation by changing the permeability of the capillaries. Bromelain and papain have been used to solubilize mucus before taking X-ray pictures of the uterus (4). They also are effective in relieving ordinary menstrual pains, when used as an irrigating solution (5).

Commercial Proteases

Although proteolytic enzymes are widely distributed in plants, micro-organisms and animals, only a few sources contain a high enough concentration of protease to be used commercially. The proteases of commerce are the crude animal proteases, pepsin, rennin, erepsin and pancreatin; the plant proteases, papain and ficin; and various bacterial and fungal proteases. Although no figures are available from the meat-packing industry regarding the production of animal proteases, rennin is probably produced and used in larger quantities than any other proteolytic enzyme. Most of it enters the manufacture of cheese. The next most important protease is probably papain, importation of which into the United States ranges from 300 to 500 tons a year. A very large percentage of the imported papain is used in beer "chill-proofing" preparations. Ficin, a proteolytic enzyme with excellent activity but frequently a strong odor, is produced on a limited scale, principally in Central America and the Middle East countries.

Since 1951 the Chemistry Department at the Pineapple Research Institute and several of the Hawaiian pineapple companies have been studying a new enzyme mixture which can be isolated from the pineapple plant, and have been producing this enzyme on a pilot plant scale. The potential production of this new enzyme preparation is large. Pineapple stem bromelain could become the most important plant protease used in the United States.

The Name, Bromelain

During the course of this investigation a large number of varieties of *Ananas comosus* (L.) Merr. and a large number of species of the family Bromeliaceae were examined for proteolytic enzymes. All plants examined contained appreciable quantities of proteolytic enzymes. In order to avoid coining new names, we have called any protease from any member of the Bromeliaceae, bromelain (3). This is in accord with the Greenberg-Winnick (2) rule for naming

plant proteolytic enzymes and is also in accord with the original use of the word bromelin, a name originally designating any protease from any member of the Bromeliaceae. The term is made specific by prefixing the binomial plant name and the organ from which the enzyme was obtained. Thus the complete

FIG. 1. Attachment of leaves, fruit and stem in a four-year-old pineapple plant.

name for stem bromelain is *Ananas comosus* var. Cayenne stem bromelain. In general usage "stem bromelain" would probably be sufficiently definitive.

Raw Material for the Enzyme

The raw materials for extraction of the enzymes are mature pineapple stems. These are collected after the final fruit harvest and are freed of the leaves and the sucker stems. Fig. 1 illustrates the attachment of leaves and sucker stems to the original stem.

The highest concentration of proteases occurs in the lower portion of mature pineapple plant stems. The central portion, the stele, contains more proteases than the outer portion, the cortex (Fig. 2). The less mature tissues, especially those that are still succulent, contain little or no detectable proteases.

TABLE I

PROPERTIES AND COMPOSITION OF PINEAPPLE STEM JUICE

Specific gravity	1.01–1.04
Soluble solids, gm./100 ml. juice	4.4–7.0
Total nitrogen, gm./100 ml. juice	0.2–0.5
"Protein" nitrogen, gm./100 ml. juice	0.08–0.22
Sugar (mostly monosaccharides), gm./100 ml. juice	2.1
Complex carbohydrates, gm./100 ml. juice	1–2
Ash, gm./100 ml. juice	0.6–0.9
pH of juice	4.6–5.4
Milk-clotting units/ml. juice *	40–150
Acid Phosphatase, mM/ml. juice †	0.106
Peroxidase, $As^{1\%}$ 400 ‡	100–300

* Milk clotting units are a measure of proteolytic activity (10).

† mM = Millimoles *p*-nitrophenol liberated from *p*-nitrophenylphosphate in one hour at pH 6.0 and 37.5° C.

‡ The absorbency at 400 mμ of the color produced by the action of peroxidase and enzyme on a guaiacol solution at pH 4.5 in 15 minutes at 37.5° C.

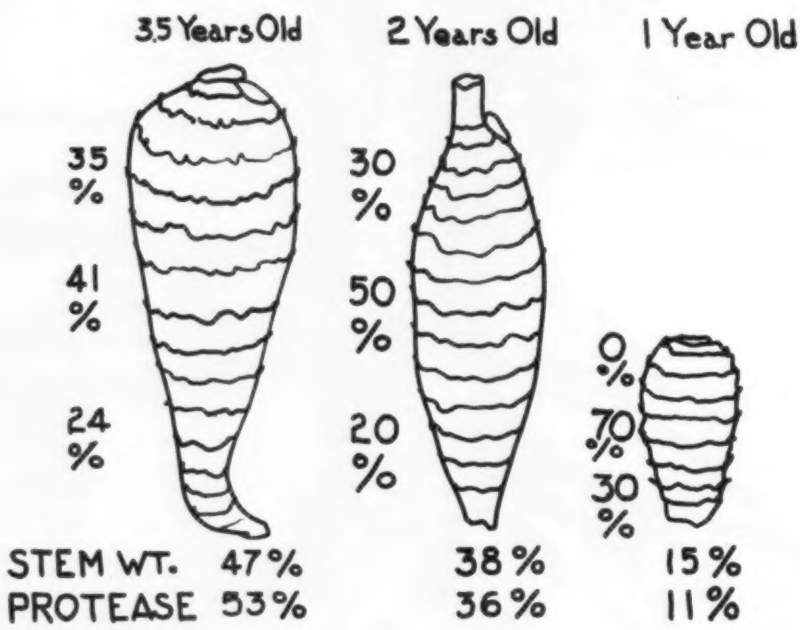

FIG. 2. Distribution of bromelain in various portions of the stem of a mature pineapple plant.

Properties of Stem Juice

The juice is a complex mixture of suspended material—starch granules, cell plastids, calcium oxalate crystals, cellular debris and soil, and soluble material such as sugars, salts, complex polysaccharides, proteins and lipids. Some of the properties of this juice are listed in Table I.

Preparation of Enzyme

Many of the classical precipitants can be used to prepare crude enzyme or certain fractions of enzymes. Ammonium sulfate, methanol, isopropanol, and acetone combined with variations in the pH of the juice have all been used in this investigation. However, for ease in preparing large batches of bromelain, acetone is the most convenient precipitant. This is the precipitant which has been employed on a pilot plant scale.

Acetone is added to the stem juices in two stages. When one to two volumes of acetone are added to two volumes of stem juice, a precipitate forms which has low enzymatic activity, poor color and very poor stability. This is discarded. Addition of another volume of acetone precipitates the main enzymatic fraction. This is collected by centrifugation and dried. This dry powder is stem bromelain. The acetone is recovered from the supernatant solution by distillation.

Chemical Properties of Stem Bromelain

Stem bromelain prepared by acetone precipitation is a mixture of many colloids, inorganic salts and simpler organic materials which are precipitated by acetone. Pure protein (trichloroacetic acid insoluble $N \times 6.25$) generally constitutes about 50% of the total weight of dried precipitate. Inorganic materials, principally cations, generally make up 10–15% of the total weight. The balance is assumed to be complex carbohydrate materials of the nature of polyuronides and glycosides. Table II gives some of the materials in stem bromelain.

TABLE II

CHEMICAL COMPOSITION OF STEM BROMELAIN

	Gm./100 gm.
" Protein " nitrogen	6.4–10
Non-protein nitrogen	0.2–3.0
Phospholipids	0.2
Complex carbohydrates	25–40
Total ash (as oxides)	10–16
Calcium	2.5–10
Magnesium	0.33
Potassium	2.89
Copper	0.002–0.020
Iron	0.06–0.114
Phosphorus	0.10–0.18

The complex carbohydrate materials are a major component of stem bromelain and affect the physical properties of the mixture. When the dried enzyme powder is added to water, the carbohydrate material forms a viscous mass which is difficult to disperse. Preliminary studies on the nature of this carbohydrate-containing material indicate that it is a mixture of at least three carbohydrate materials which can be precipitated by acetone. Several of these materials are acidic. One of the acids, based on the carbazole test, is a polyuronide. The salts of these organic acids account for most of the high content of inorganic cations.

Physical Properties of Bromelain

The electrophoretic pattern of stem bromelain is complex. Commercial stem bromelain preparations contain from five to eight electrophoretically distinct peaks (Fig. 3), a truly complex pattern for a plant protein preparation. Three of the electrophoretically distinct components, which may make up 60–80% of the total pattern area, have isoelectric points ranging between pH 9.2 and pH 11.0. The only other plant protein preparations that have been described and which also contain many basic proteins are the dried latexes of *Carica papaya* and *Ficus* sp., namely, papain and ficin.

Peaks B and C in Fig. 3 represent the colloids containing most of the proteolytic activity of stem bromelain. However, a very active protease is also asso-

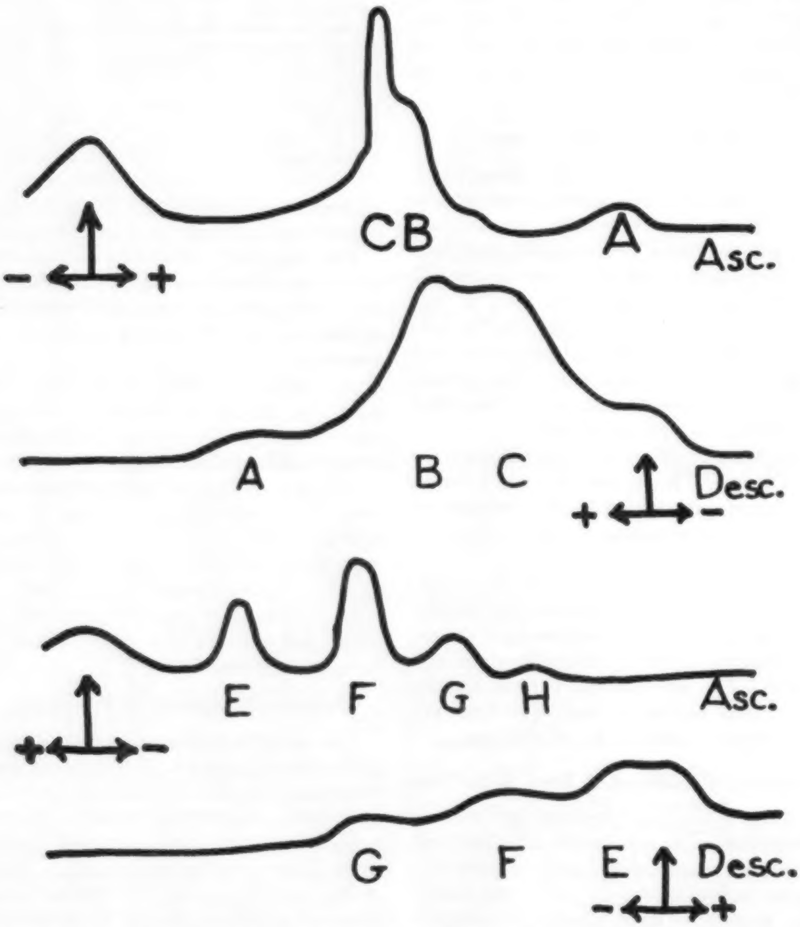

FIG. 3. Two-hour electrophoretic patterns of commercial bromelain showing seven distinct peaks labelled A through H. The separation was made at pH 6.5 in a 0.1 ionic strength buffer.

ciated with the colloids represented by peaks E or F which have isoelectric points near pH 5. Peak G in all the experiments made to date has shown no trace of proteolytic activity; intense acid phosphatase activity is associated with this peak. Most of the peroxidase activity is concentrated in the components represented by peaks E and F.

Enzymes in Stem Bromelain

Stem bromelain contains several proteases which differ from each other in their action on different substrates, in

their susceptibility to oxidizing and reducing agents, and especially in the pH value at which they hydrolyze their substrates most rapidly. The pH value of optimum digestion is influenced by the nature of the substrate, by the concentration and type of buffer, and by the presence of reducing agents. To aid in classifying these enzymes, the proteases are designated by the pH value at which they exhibit their optimum activity. Curves made by plotting the amount of digestion against the pH of the substrate solution indicate that stem bromelain is a mixture of four proteases (Figs. 4 and 5).

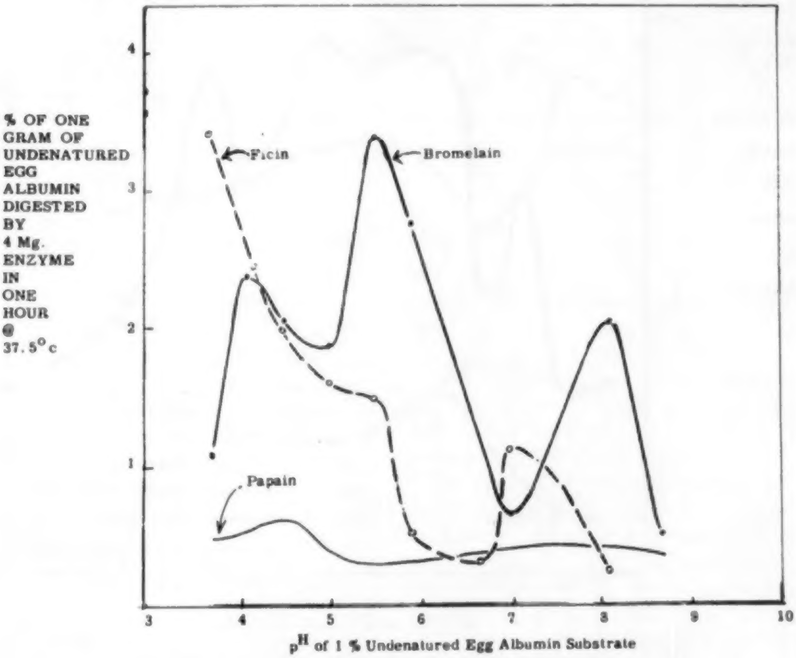

Fig. 4. Digestion of undenatured egg albumin by bromelain, papain and ficin.

Certain preliminary generalizations regarding the proteases can be made from digestion studies, using commercial bromelain as a source of enzyme. Bromelain pH 4.5 and bromelain pH 5.5 show many similarities. Both split certain peptide linkages which are found in gelatin. However, after these have been hydrolyzed, they attack other linkages very much more slowly. Both bromelains attack undenatured egg albumin at pH values 0.5 unit lower than their pH optima on gelatin. Cysteine accelerates the hydrolyzing action on egg albumin.

There are certain differences between these two bromelains. Bromelain pH 5.5 attacks hemoglobin-urea mixtures and lactalbumin much more readily than does bromelain pH 4.5. The latter enzyme will, however, attack hemoglobin from which the urea has been removed by dialysis. At pH 4.0 one of the proteases in the mixture will hydrolyze Bactopeptone.

Bromelain pH 7.0 and bromelain pH 8.5 hydrolyze such proteins as casein, denatured hemoglobin, and lactalbumin. They are not so active in hydrolyzing gelatin as is bromelain pH 4.5 or pH 5.5. The ratio of these enzymes varies in different preparations. Bactopeptone is hydrolyzed very extensively at pH 7.5. Benzoylarginamide is hydrolyzed at pH 7.0.

The role of sulfhydryl groups in these proteases is uncertain. Certain typical sulfhydryl poisons, such as heavy metals and oxidizing agents, are potent bromelain poisons. On the other hand, the very specific sulfhydryl reagent, N-ethylmaleimide (N.E.M.), is not an inhibitor until several hundred moles of N.E.M. are used per mole of enzyme. Bromelains which are true sulfhydryl enzymes can be prepared by precipitating the enzymes near neutrality.

In addition to these proteases, stem bromelain also contains several other enzymes. It is a rich source of acid phosphatase. This is a relatively stable enzyme and does not deteriorate rapidly upon storage. When freshly prepared, it contains peroxidase. However, in contrast to the storage stability of the acid phosphatase, pineapple stem peroxidase is very labile. After three to six months storage the peroxidase content practically disappears. This behavior is similar to *Carica papaya* fruit latex peroxidase.

Table III lists certain enzymes which have been found in commercial bromelain and other plant proteases.

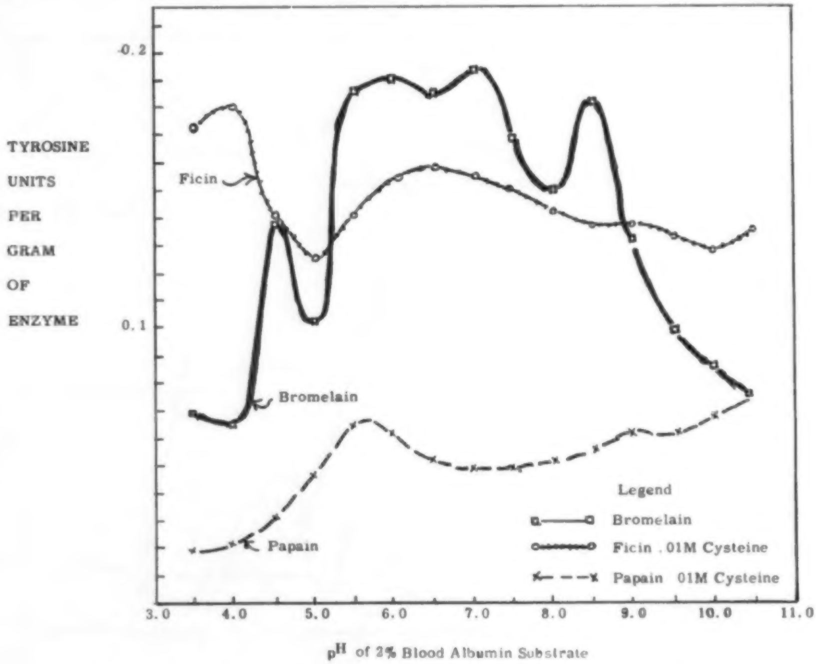

FIG. 5. Digestion of blood albumin by bromelain, papain and ficin.

TABLE III
ENZYMATIC ACTIVITY OF SEVERAL PLANT PROTEASES

	Bromelain		Papain	Ficin
	Stem	Fruit		
Milk-clotting units/gm.	2,000–5,000	800–2,500	300–2,000	2,000–5,000
Activated M.C.U./gm.	2,000–5,000	800–2,500	800–2,000	3,500–5,200
Acid Phosphatase, mM./gm.	3–5	3–5	Neg.	Neg.
Peroxidase, ascorbic acid unit/gm.	0–8,000	.....	0–500	50,000–80,000
Catalase	Trace	.....	.....	.....
Gel. dig. units, pH 4.5	1,000–2,200	800–1,500	200–500	1,500–2,200
Gel. dig. units, pH 5.5	1,000–2,600	500–1,200	200–400	1,500–2,200
Tyrosine dig. units/mg., pH 7.0	190	.....	5	100
Tyrosine dig. units/mg., pH 8.5	180	.....	70	150
Gel. liq. units	12,000–18,000	7,000–10,000	1,700–3,000	3,000–5,000
Oxidase	Laccase	.....	Yes	Yes
Amylase	Trace	None	None	None
Amidase	None	None	None	None
Asparaginase	None	.....	.....	.....
Glutaminase	None	.....	.....	.....
Urease	None	None	.....	.....
Pectinesterase	Trace	.....	Yes	Yes

Stem Bromelain, the Ideal Plant By-Product

In many respects the production of stem bromelain could well become a classical example of an ideal by-product operation. The distribution of the work load is excellent in relation to both canning and land preparation operations. The peak of the stump harvest and the production of enzyme occur when the fruit harvest is generally low. Thus part of the personnel and equipment, such as trucks used in transporting fruit, could also be used to transport stumps. Furthermore, the stump harvesting operation would replace the first phase of preparing the land for a new crop of pineapple plants. Normally, if the stumps are not removed, they are destroyed by chopping with discs or by crushing them between rollers, by disintegrating them by rototillers, followed by plowing them into the ground in several plowing operations.

Production of stem bromelain yields several other by-products. While none of these by itself, such as starch and cattle feed, is valuable enough to warrant harvesting stumps, they help to defray part of the operating costs.

Stem bromelain has a high value per unit of weight. Thus shipping costs make up a relatively small part of the delivered value of the product.

The source of the by-product is a highly standardized crop which is grown in an area subject to a minimum of climatic vagaries. For the purchaser of enzyme this is a very important consideration. It assures him of a constant supply of uniform enzyme at a relatively stable cost.

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Utilization Abstracts

Seed Protection. The use of a biologically active substance to protect seeds against disease has been practised in one form or another for centuries. Only in very recent times, however, have dual-action seed dressings been developed to protect crops against loss caused by both seed-borne disease and insect pests. Economic advantages are obvious. Substance used as insect repellent was " Granadin ". (C. P. Hampson, A. Marshall and W. S. Norris, *Chem. Prod. 20(6): 227–230. 1957.)*

Essential Oil of Coriander. *Coriandrum sativum* L. was the only acceptable substitute for pepper for Jugoslavs when foreign sources were not available in World War II. 1000–2000 hectares of land are devoted to growing the spice. After the war, production of the essential oil of coriander (*Aetheroleum Coriandri*) began. Culture is best on deep garden loam of limestone origin. Production has side effect for honey crop. Bees favor the plant over others. Small fruited varieties are selected for greatest oil yield. Crushing the fruit before extraction gives 15 percent increase in yield of oil. (Y. Tucakov, *Perf. and Essent. Oil Rec. 48(5): 212–216. 1957.)*

Antioxidants. Linseed oil (*Linum usitatissimum*) is used extensively in Egypt as an edible oil. Producers of linseed oil consider that admixtures of oil of garden cress (*Lepidium sativum*) and wild mustard (*Sinapsis* (*Brassica*) *amensis*) retards oxidation of the oil. Ten percent concentration of either admixture was found effective; higher percentages produce no additional effect. Differences in protective values exist, dependent on whether linseed oil is expressed or extracted. For the expressed linseed, a protective value of two is conveyed by either oil, and for the extracted oil, either admixture gives a protective value of four. Differences in protective value depend on amount of tocopherol contained in linseed. Experimental results show that the only antioxidant of both plants is alpha-tocopherol. (M. Lotfy, H. Aref and A. A. Hussein, *Jour. Am. Oil Chem. Soc. 34 (5): 96–100. 1947.)*

Antioxidants from Tomatoes. Highly active antioxidants for lard were extracted from dried tomato fruits with petroleum ether. When added to fresh lard, the tomato lipids protected against oxidation at 100° C. for long periods with little accumulation of peroxides during the induction period. When added at two percent levels to actively oxidizing lard (peroxide values 20–130), the tomato lipids effected a rapid drop of approximately 25% in titrable peroxides. At eight percent, tomato lipids effected immediate drop, and a second more gradual drop to a constant low value (ca. 5). Antioxidant properties due to two fractions: one a primary antioxidant, the other of a synergistic (potentiating) substance. (R. E. Heuze and F. W. Quackenbush, *Jour. Am. Oil Chem. Soc. 34(1): 1–4. 1957.)*

The Edibility of Shoots of Some Bamboos Growing in Puerto Rico

In China and Japan bamboo shoots have long served as victuals, but no such use has yet developed in the New World, except for imports of the canned article. Edibility tests on 27 kinds growing in Puerto Rico are here reported, but large plantations and propaganda to create a demand for the shoots would be necessary to establish them as items of diet in America.

WILLIAM C. KENNARD[1] AND RUBÉN H. FREYRE[1]

Introduction

Bamboos are perennial grasses which exhibit great variation in culm height and diameter, and which are used for hundreds of different purposes. Widely known as a construction material and as a source of paper pulp, bamboos offer an important additional usage—utilization of the young shoots as food. This is particularly well developed in the Far East and in India.

Bamboos are divided into two classes on the basis of their vegetative growth habit: sympodial or clump-forming, and monopodial or running types. Bamboos of the former type produce rhizomes which grow horizontally from the base of an existing culm and then turn up to form the new shoot. The rhizomes of some species grow horizontally only a few inches before turning up and thus form very compact clumps (Fig. 1, upper). Those of other species grow horizontally several feet and form open clumps (Fig. 1, lower). Bamboos of the monopodial type have underground stems, called "rhizomes", which grow indefinitely in a horizontal position. New culms arise from lateral buds on the rhizomes and form what is best termed a thicket. The clump-forming bamboos generally are tropical types, whereas the running bamboos usually are in temperate regions of the world.

Shoots of both running and clump-forming bamboos are utilized as food. In northern China, shoots of *Phyllostachys edulis* (Carr.) H. de L. are most commonly found in the markets (3). In Japan, *Phyllostachys mitis* A. and C. Riviere has been reported to yield the most palatable shoots (2). According to McClure (3), the edible bamboo shoots consumed in southern China come chiefly from sympodial types belonging to the genera *Bambusa* and *Dendrocalamus*. Ochse (5) lists four species of *Bambusa*, one of *Dendrocalamus* and five of *Gigantochloa* as being used for food in the Dutch East Indies (Indonesia).

Young (8) in 1954 reported the results of evaluating 20 kinds of bamboos. Most of these were of the monopodial or running type from the Orient. He concluded that all 16 species of *Phyllostachys* which he evaluated were edible. Three of them lacked acridity in the raw state, but two had considerable acridness. The remaining species were found to have varying small degrees of acridity when tasted in the raw state. Two additional sympodial bamboos, *Arundinaria simonii* var. *variegata* Hook. f. and *Pseudosasa japonica* (Stendel) Makino, lacked acridity when tasted raw.

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FIG. 1 (Upper). New shoots and mature culms of clump-forming *Bambusa polymorpha* Munro. Note the compactness of the clump.

FIG. 1 (Lower). New shoots and mature culms of clump-forming *Guada angustifolia* Kunth. New shoots of this species grow horizontally several feet before turning up and thus form open clumps.

Bamboo shoots are seldom served on the tables of American homes, but large quantities of imported shoots are consumed in the United States, mainly in Chinese restaurants. At present canned shoots are secured principally from Japan, Formosa and Hong Kong. Since many bamboos grow well in Puerto Rico, it is possible that an American source could be developed to supply the demand for canned shoots. Furthermore, the shoots might prove to be a welcome addition to the diets of people in the American Tropics.

Although only small-caned, climbing types of bamboos of the genera *Chusquea* and *Arthrostylidium* are native to Puerto Rico, the Federal Experiment Station at Mayaguez has introduced and planted many bamboos which produce medium-size to large culms. The experiment reported in this article was conducted to evaluate shoot edibility of some of the bamboos growing in this collection.

Procedure

Shoots from mature clumps of 27 bamboos representing ten genera were selected for study. Three genera, *Melocanna, Phyllostachys* and *Schizostachyum,* were of the running type. The remaining seven were of the clump-forming or sympodial type. Shoots to be evaluated were cut off level with the ground when they reached a height of 12 to 22 inches. The length and greatest diameter in inches and the weight in grams of each shoot, together with the color and appearance of the culm sheaths, were recorded. The shoots were prepared for processing by cutting through the culm sheaths lengthwise and removing them. The base of the shoots usually is tough, and this portion was removed until the knife blade cut readily through the shoot. The part remaining was weighed so that the percentage of edible portion could be calculated. The flavor of the edible portion was evaluated organoleptically. The shoots then were cooked in boiling water or in a salt solution (two tablespoonfuls of sodium chloride per quart of water) for 15 minutes. Other treatments, such as changing the salt water and reboiling, or addition of sodium bicarbonate, were necessary to render some shoots palatable. After processing, the shoots were evaluated for color, texture and flavor[2]. Finally, on the basis of general canning quality, each bamboo species was placed in one of the following categories: excellent, good, fair, and unsatisfactory.

Results and Discussion

Shoots of the various bamboos showed great variation in size and weight. The basal diameters ranged from about one inch for *Bambusa multiplex* (Lour.) Raeusch. to slightly over nine inches for *Dendrocalamus asper* (Schult.) Backer. The extremes of fresh-shoot weight before peeling (Table I) are represented by shoots of *Bambusa textilis* McClure and *Dendrocalamus asper,* which weighed 135 and 5,395 grams, respectively. It is of interest to note the variation in shoot weight of the 12 species of *Bambusa* which were evaluated. The largest shoots, averaging 2,679 grams each, were produced by *Bambusa arundinacea* Retz. This was followed closely by *B. vulgaris vittata* A. and C. Riviere, with an average weight of 2,335 grams, and *B. vulgaris* Schrad. ex Wendl., with 2,085 grams. The lightest shoots were produced by *B. textilis* and *B. multiplex.* Shoots of *B. arundinacea* were approximately 20 times as heavy as those of *B. textilis.*

The value of a given bamboo shoot as food is based not only on its total fresh weight but also on the percentage of the shoot which is edible. The edible por-

[2] The authors are indebted to Mr. David H. Bau, Cathay Restaurants, Inc., Santurce, Puerto Rico, for processing the shoots and for evaluating canning quality.

TABLE I

WEIGHT AND EDIBILITY CHARACTERISTICS OF THE SHOOTS OF 27 SPECIES AND TYPES OF BAMBOO GROWING IN PUERTO RICO

Species	Shoots tested	Average fresh weight		Edible portion	Edible portion (raw) Flavor	Edible portion (cooked)			Canning quality
		Before peeling	After peeling			Flavor	Color	Texture	
	Number	*Gms.*	*Gms.*	*Percent*					
Bambusa arundinaceae Retz.	8	2,679	1,011	38	Bitter	Trace bitter	Yellowish	Tender	Fair
B. longispiculata Gamble ex Brandis	5	1,137	311	27	Slightly bitter	Slightly bitter	Creamy	"	"
B. multiplex (Lour.) Raeusch.	4	196	75	38	Very bitter	Very bitter	Greenish white	"	Unsatisfactory
B. mutabilis McClure	4	301	49	16	Bitter	Bitter	Creamy	Tough	"
B. pervariabilis McClure	2	962	140	14	Very bitter	Very bitter	"	"	"
B. polymorpha Munro	8	1,385	168	12	Sweet	Sweet	Creamy white	Tender	Excellent (best)
B. textilis McClure	6	135	30	22	Bitter	Bitter	Light pink	Tough	Unsatisfactory
B. tulda (new) Roxb.	4	961	175	18	"	Slightly bitter	Creamy white	"	"
B. tulda (old) Roxb.	2	378	84	22	Very bitter	Bitter	Creamy	Tender	"
B. tuldoides Munro	5	938	137	15	Bitter	"	"	Tough	"
B. ventricosa McClure	4	804	161	20	Very bitter	Very Bitter	Light pink	Fibrous	"
B. vulgaris Schrad. ex Wendl.	14	2,085	375	18	Bitter	Not bitter	Whitish pink	Tender	Fair
B. vulgaris vittata A. and C. Riviere	2	2,335	1,046	45	Slightly bitter	Trace bitter	Pink	"	"
Cephalostachyum pergracile Munro	4	825	168	20	Bitter	Bitter	Creamy	Tough	Unsatisfactory
Dendrocalamus asper (Schult.) Backer	3	5,395	1,846	34	Trace bitter	Trace bitter	"	Tender	Good
D. giganteus Munro	4	1,653	550	33	Very bitter	Not bitter	"	"	Fair
D. membranaceous Munro	3	1,167	461	40	Slightly bitter	Slightly bitter	Creamy white	"	Excellent
D. strictus (Roxb.) Nees	5	1,657	458	28	Bitter	Bitter	Pink	Tough	Unsatisfactory
Gigantochloa apus (Schult.) Kurz ex Munro	4	437	105	24	"	"	"	"	"
G. levis (Blanco) Merr.	3	2,780	630	23	"	Not bitter	White	Tender	Good
Guadua angustifolia Kunth.	8	3,592	668	18	Sweet	Slightly bitter	Light pink	"	"
Lingnania fimbriligulata McClure	3	998	112	11	Bitter	Bitter	" "	Tough	Unsatisfactory
Melocanna baccifera (Roxb.) Kurz	5	353	137	39	Slightly bitter	Sweet	Greenish white	Tender	Good
Phyllostachys bambusoides Sieb. & Zucc.	1	140	28	20	Bitter	"	Green	Tough	Unsatisfactory
Schizostachyum funghomii McClure	4	473	98	21	Slightly bitter	"	Creamy	"	"
Sinocalamus beecheyanus (Munro) McClure	6	2,722	692	25	" "	Trace bitter	White	Tender	Fair
S. oldhami (Munro) McClure	5	1,654	458	28	Bitter	Sweet	"	"	Good

tion of the bamboos evaluated ranged from 11 percent for *Lingnania fimbriligulata* McClure to 45 percent for *Bambusa vulgaris vittata*. The average amount of edible portion for all species was 27 percent, a figure almost identical with that given by Wu Leung, Pecot and Watt (7) for *Bambusa* and *Phyllostachys* spp. In general, the amount of fiber present, which is correlated with the amount of edible portion, increases with increasing height of the shoots. Environmental conditions, however, no doubt influence this character. Further, it was noted that shoots collected late in the rainy season tended to be tougher and more fibrous than those collected when new shoots first began to appear.

Only two species, *Bambusa polymorpha* Munro and *Guadua angustifolia* Kunth., were found to produce shoots with a distinctly sweet taste in the raw state. Seven species were only slightly bitter or acrid. These were two species of *Bambusa*, two of *Dendrocalamus*, and one each of *Melocanna*, *Schizostachyum* and *Sinocalamus*. Shoots of the remaining bamboos were bitter or very bitter in the raw state. Species within the genus *Bambusa* varied as greatly with respect to flavor as they did in shoot size and weight. One, *B. polymorpha*, was

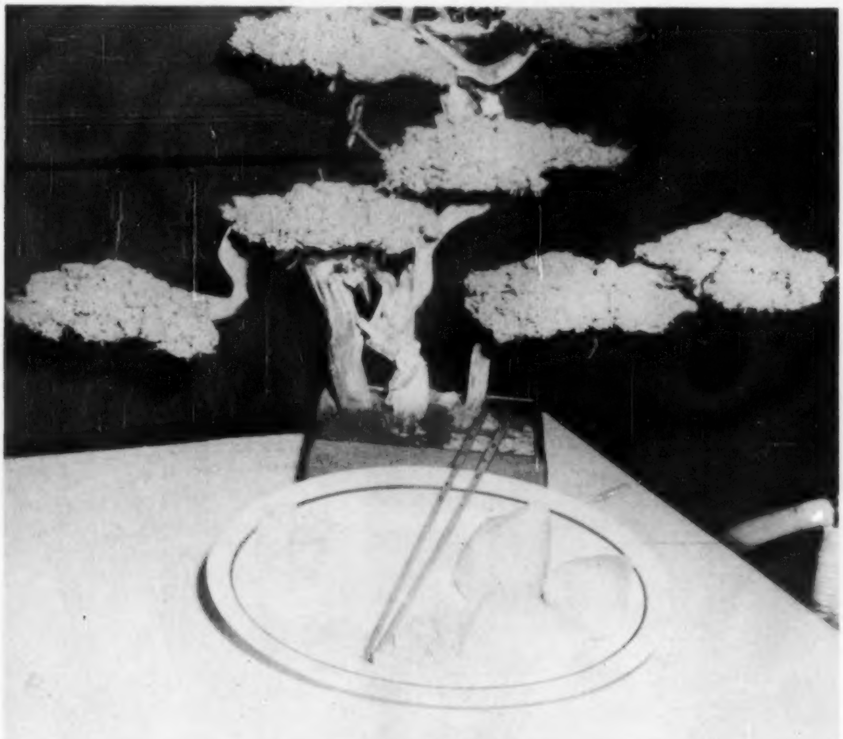

FIG. 2. Bamboo shoots prepared for eating. Shoots are not usually eaten alone but are cut into fancy shapes and combined with other foods such as rice, bean sprouts and mushrooms.

sweet, whereas *B. multiplex*, *B. pervariabilis* McClure, *B. tulda* (old) Roxb. and *B. ventricosa* McClure shoots were very bitter.

The ideal edible bamboo for processing should be white, solid and tender, and should lack bitterness or acridness. Shoots prepared for consumption are shown in Fig. 2.

On the basis of evaluation after processing, shoots of *Bambusa polymorpha* were judged best of those tested (Fig. 3). The shoots are creamy-white, tender, and have a sweet, pleasant taste. This bam-

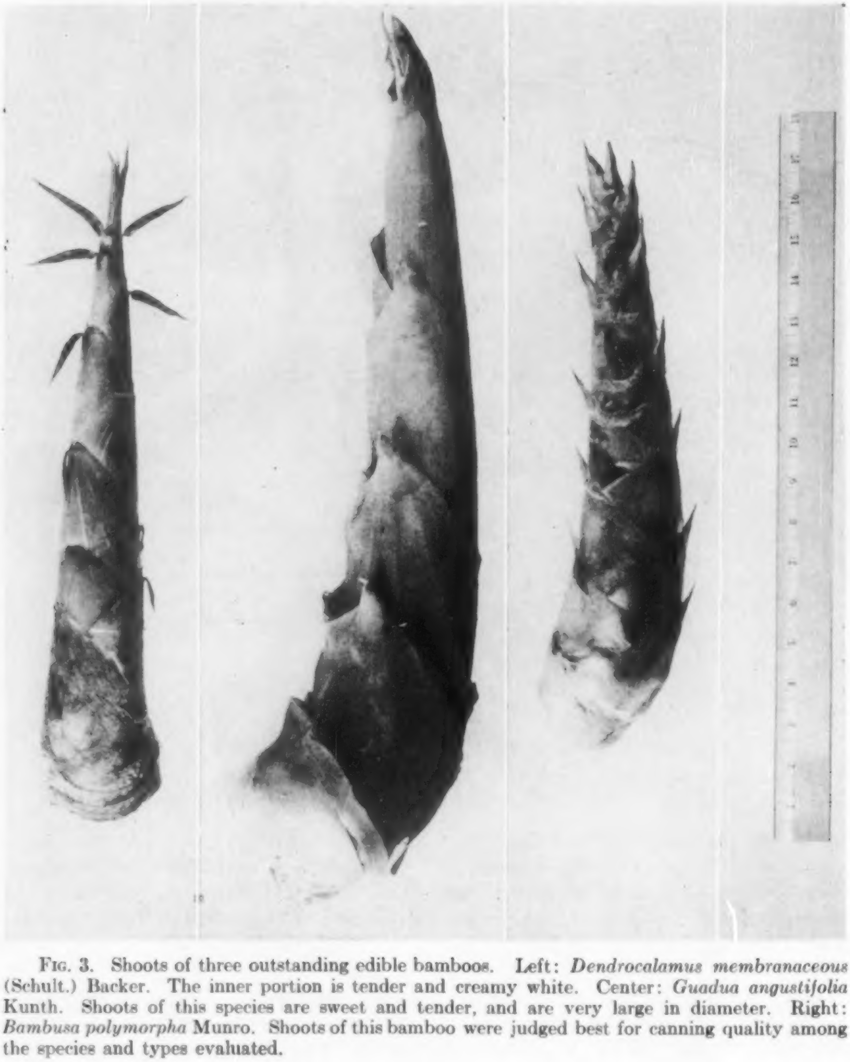

FIG. 3. Shoots of three outstanding edible bamboos. Left: *Dendrocalamus membranaceous* (Schult.) Backer. The inner portion is tender and creamy white. Center: *Guadua angustifolia* Kunth. Shoots of this species are sweet and tender, and are very large in diameter. Right: *Bambusa polymorpha* Munro. Shoots of this bamboo were judged best for canning quality among the species and types evaluated.

FIG. 4. A mature clump of *Bambusa polymorpha* Munro. This bamboo usually is evergreen but drops its leaves in areas with a dry season or during periods of extended drought.

boo, a native of India, forms a large, compact clump (Fig. 4) with culms up to four inches in diameter and 40 to 50 feet in height. It is deciduous in areas such as western Puerto Rico, which have a distinct dry season. The culm sheaths are dark brown, possess numerous hairs, and have thorny tips.

Shoots of *Dendrocalamus membranaceous* Munro (Fig. 3), another Indian species, also were judged to be excellent from a processing point of view. This bamboo produces culms up to three inches in diameter and 35 feet in height. It forms a very compact clump, and the culms sometimes are twisted. The culm sheaths are pinkish-green and lack hairs. The smoothness of the culm sheaths is an advantage, since the types with hairs are difficult to handle—the hairs often tend

to stick in the fingers as the sheaths are removed from the shoots.

Shoots of the following five species were judged to be good: *Dendrocalamus asper*, *Gigantochloa levis* (Blanco) Merr., *Guadua angustifolia* (Fig. 3), *Melocanna baccifera* (Roxb.) Kurz, and *Sinocalamus oldhami* (Munro) McClure. The remaining species were fair or unsatisfactory for processing because they were off-color, tough or bitter, or possessed a combination of these factors.

The only running type of bamboo tested in this experiment and also tested by Young (8) was *Phyllostachys bambusoides* Sieb. and Zucc. Young found raw shoots of this species to have considerable acridity, and a similar flavor evaluation was given for it in the tests reported in this paper. Two other bamboos, both clump types, tested by Young also were evaluated in Puerto Rico. These species, *Bambusa arundinacea* and *Sinocalamus beecheyanus* (Munro) McClure, possessed considerable acridness in the raw state and were only fair in regard to canning quality.

From a home consumption point of view most bamboo species are edible, since the bitterness or acridness usually can be removed by changing the water several times during cooking. Toughness can be ameliorated by cutting the shoots into very thin slices. Color, of course, is relatively unimportant from a home-consumption point of view. Shoots of *Bambusa vulgaris* fall in this category, since they were judged to be only fair commercially, mainly because they possess an undesirable pinkish color. Preliminary investigations at this station, however, have shown that development of the pink color can be prevented (6). This bamboo, most generally considered to be a native of Madagascar (4), is widely distributed in tropical regions of both the Western and Eastern Hemispheres. *B. vulgaris* is the only bamboo which is abundant in Puerto Rico where it is frequently found in the lowlands, especially along the banks of rivers and streams. Shoots of *B. vulgaris*, therefore, could form the basis for a commercial canning industry in this island until plantings of more desirable bamboo species could be established.

New shoot production of most bamboo species in western Puerto Rico begins in late May or early June, about two months after the rainy season commences. Shoots are produced for a period of one to four months, depending upon the species. An individual culm is of full diameter as it emerges from the soil, and growth in height is completed in two to five months. It appears feasible to remove some new shoots for eating purposes as a bamboo clump normally starts many more than it matures. Brown (1) reported that clumps of *Bambusa spinosa* Roxb. yearly sent up as many as 130 shoots, a considerable portion of which died before reaching maturity. Sufficient new shoots should be allowed to mature, however, to mantain the clump in a healthy and vigorous condition.

Although not outstanding in food value or vitamin content (7), bamboo shoots could be a welcome addition to the diets of many peoples in tropical America. The development of a canning industry, however, would be dependent upon the establishment of large plantings of the species which produce the best shoots. Several of the bamboos now growing in Puerto Rico, particularly *Bambusa polymorpha* and *Dendrocalamus membranaceous*, are well suited for this purpose.

Summary

Evaluation of the edibility of young bamboo shoots growing in Puerto Rico showed that great variations in size and quality exist among the 27 types and species tested. These variations prevail

among species of the same genus as well as among the ten genera investigated.

Shoots of only two species, *Bambusa polymorpha* and *Guadua angustifolia*, were found to have a sweet taste in the raw state. Shoots of the other bamboos possessed varying degrees of bitterness or acridness.

After processing, shoots of seven species were judged to be outstanding in canning quality. Two of these, *Bambusa polymorpha* and *Dendrocalamus membranaceous*, were judged to be excellent.

The development of a commercial bamboo-shoot canning industry would be dependent upon the establishment of plantings of the best species. Shoots of most bamboos can be eaten when correctly processed, however, and could be utilized by people in the American Tropics.

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Utilization Abstract

Native Grass Seed. The use of native grasses for field borders, headlands and wildlife cover in the more humid Corn Belt states of the Great Plains has not been practiced widely. One of the difficulties which prevents wide acceptance is the problem of producing good seed. However, if good seed practices are followed under cultivation in production fields, then normal yields can be expected. Results of trials at the Soil Conservation Service Nursery at Ames and Ankeny, Iowa, over a ten-year period, in fields of 1 to 10 acres for each grass, planted in rows 36 inches apart, cultivated for weed control and fertilized with an average of 200 pounds of ammonium nitrate per acre in early spring support this.

The native grasses used in these trials are: Tall wheatgrass (*Agropyron* sp.), intermediate wheatgrass (*Agropyron intermedium*), big bluestem (*Andropogon gerardi*), tall oatgrass (*Arrhenatherum elatius*), side-oats grama (*Bouteloua curtipendula*), smooth bromegrass (*Bromus inermis*), orchardgrass (*Dactylis glomerata*), Canada wild-rye (*Elymus canadensis*), Virginia wild-rye, sand lovegrass (*Eragrostis trichodes*), tall fescue (*Festuca elatior* var. *arundinacea*), Blackwell switchgrass (*Panicum virgatum* Hort. var. Blackwell), reed canarygrass (*Phalaris arundinacea*), yellow indiangrass (*Sorghastrum nutans*).

Cost per pound of pure live seed for several warm and cool season grasses are presented in table form. (Virgil B. Hawk, *Crops & Soils 9(9): 18–19. 1957.*)

New Germ Plasm—*The Merits and Uses of Some Plant Introductions*

The value of the U. S. Department of Agriculture's Plant Introduction Program, and some examples of introductions of new varieties for increased yield, disease, and insect resistance are discussed.

DESMOND D. DOLAN [1]

INTRODUCTION

Most of our major crops are of foreign origin. For at least 400 years plants have been introduced from foreign sources but a great diversity of germ plasm still remains in the centers of origin. Since 1898 the New Crops Research Branch of the United States Department of Agriculture has introduced, named botanically, and assigned P.I. numbers to more than 234,000 plant accessions. Disease resistance, frequently inherited as a single dominant factor, and also many desirable horticultural and agronomic characters have been found in these introductions. With wider use of the backcross as a method of incorporating a desirable trait into an otherwise satisfactory variety, it is evident that plant breeders will depend to a large extent on the plant introduction program for new germ plasm to be used in crop improvement.

FEDERAL PLANT INTRODUCTION PROGRAM 1898–1957

In 1898 the scattered plant introduction activities of the Department of Agriculture were organized and concentrated into what is now known as the New Crops Research Branch. During the next 30 years the plant materials introduced were not utilized to their fullest, for research workers of that period were mainly concerned with studies of crop varieties already in existence. Since 1928 the greater emphasis on the part of the plant breeder in developing new, or improving old, varieties through the use of the wealth of genes to be found in areas of origin of our major crops has provided new impetus to the Branch's activities. As a result, the demand by plant breeders for introductions containing disease or insect resistance or other desirable qualities soon outgrew the Branch's facilities for such service.

In 1948 increased funds for the support of this work afforded the Branch an opportunity to decentralize its work and develop formal cooperation with the State Experiment Stations. The United States was divided into four regions, each headed by a regional coordinator responsible for preliminary evaluation, seed increase and placement of introduced plants in his region.

The Regional Station at Geneva, New York, was established on October 15, 1953. It serves experiment station personnel and commercial breeders in the 12 states (6 New England states, New York, Pennsylvania, New Jersey, Delaware, Maryland and West Virginia) of the Northeast Region. Since its beginning, the Station at Geneva has aver-

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FIG. 1. *Cucumis sativus*, PI 227208, from Japan, exhibiting resistance to mosaic and downy mildew.

FIG. 2. *Cucurbita maxima*, PI 224670 (Balkabage squash), from Turkey. An early-maturing, high-quality, orange-red turban.

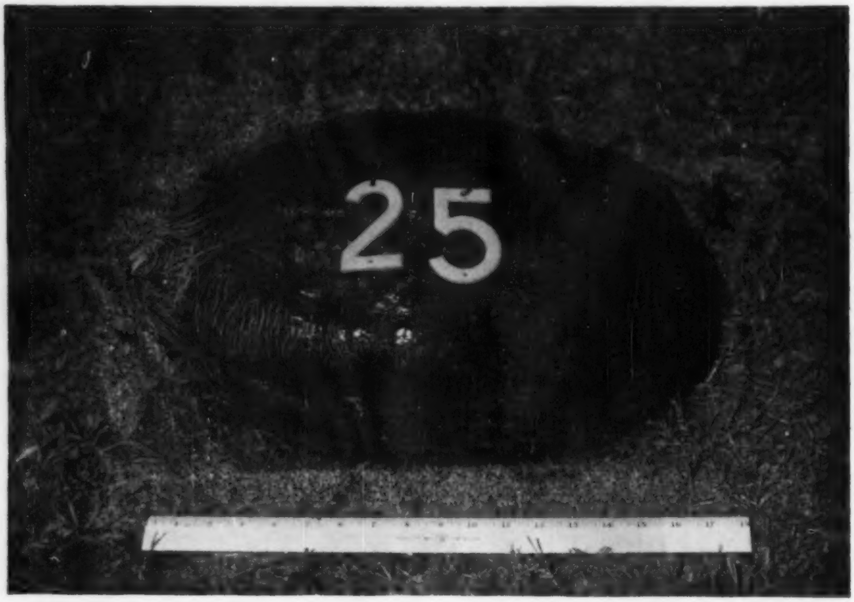

FIG. 3. *Cucumis melo,* PI 214048, a large, bumpy, black muskmelon from India. It measured 18 × 13 inches.

FIG. 4. *Medicago sativa,* PI 217419, from Denmark on right, as compared to two standard American varieties of alfalfa on left. Note longer branches and larger leaves.

aged approximately 1,000 incoming plant introductions each year and has complied with 1,500 requests annually for plant materials.

MERITS OF PLANT INTRODUCTIONS

New Varieties from Plant Introductions

Most plant introductions are not sufficiently adapted or uniform for immediate propagation and release. In the majority of cases, the plant breeder must be content with drawing only one or at best a few desirable traits from any specific introduction. Repeated crossings and much selection may be required to screen out undesirable features and to incorporate into a new variety only the desired traits.

There are, however, a few cases where introduced plant materials have been propagated and released with very little change. Birdsfoot trefoils (*Lotus corniculatus* L.) from Europe have been fitted to the forage program of the northeastern states by merely selecting plants best adapted to the new environment. (Empire, 1948; Viking, 1955). The Richmond Wonder bean, released by the Montana Agricultural Experiment Station in 1956, came from Australia as P.I. 151062. It is a dwarf French bean with resistance to halo blight and common bean mosaic and is a consistently high yielder. The Takii Gem watermelon (P.I. 229806), a small early maturing type introduced from Japan about five years ago, is presently cataloged by prominent seedsmen of the Northeast.

Disease Resistance from Plant Introductions

The small red currant tomato (*Lycopersicon pimpinellifolium*) provided us with a high degree of resistance to at least seven diseases, and resistances to many of these were controlled by a single dominant gene. Another small tomato (*L. peruvianum*) provided us with high

FIG. 5. *Pisum sativum*, PI 140295, from Iran, provided resistance to enation virus disease which was threatening the pea industry of western New York.

FIG. 6. *Citrullus vulgaris*, PI 229806, Takii Gem watermelon from Japan. Now catalogued by commercial seed companies as an early watermelon for western New York.

resistance to at least three diseases and several valuable horticultural characters as well. Since the introduction of "Pan America" in 1941, most new tomato varieties have carried germ plasm of these wild tomato species from South America. Just recently a cherry tomato (*L. esculentum* var. *cerasiforme*, P.I. 224675) from Mexico has proven resistant to late blight and is being used in several breeding programs.

About 1940, mosaic resistance was found in two oriental cucumbers and these resistances were dissimilar. One variety named "Tokyo Long Green", proved capable of warding off attack by the mosaic virus, as indicated by the fact that plant extracts were noninfec-

tious. The other, named "Chinese Long", became infected, as evidenced by the fact that terminal leaves frequently were mottled and extracted juice was infectious. H. M. Munger and coworkers at Cornell found that resistance superior to that of either parent could be developed by crossing these two oriental cucumbers and selecting from the progeny. New varieties recently introduced in New York, Ohio and Canada carry the germ plasm of these mosaic-resistant cucumbers.

A seven-year program of screening pea introductions for disease resistance at the New York State Agricultural Experiment Station has brought to light the following promising genetic material:

a) From Iran, an introduction (P.I. 140295) displaying immunity to enation virus.

b) From Mexico, an introduction (P.I. 201497) with resistance to powdery mildew.

c) From Ethiopia, an introduction (P.I. 175227) showing tolerance to *Aphanomyces* root rot.

d) From India, Peru, Turkey and Ethiopia, 16 introductions carrying tolerance or resistance to Fusarium root rot.

A spinach from Iran (P.I. 140467) was found to carry a single dominant factor for immunity from downy mildew (*Peronospora effusa*). This resistance was recently used by H. A. Jones in the breeding of Early Hybrid No. 7 variety.

Insect Resistance from Plant Introductions

Very little screening of plant introductions for insect resistance has been conducted. Detection of insect resistance has depended upon field observation which frequently leads to confusion of resistance with disease escape. Even with this meager beginning, the Plant Introduction Station at Geneva at present has on inventory five melons (P.I. Nos. 164617, 164723, 164756, 172831, and 210541) claimed resistant to the striped cucumber beetle (*Acalymma vittata*); two alfalfas from Peru (P.I. 151671 and 205329) resistant to leaf hopper (*Empoasca fabae*); and three eggplants (P.I. 230333–35) from Japan resistant to the tarnished plant bug (*Lygus lineolaris*).

CONCLUSION

Apparently the need for new germ plasm will continue and may become demanding. It will persist as long as there is a possibility of improving present varieties in disease- and insect-resistance or in horticultural and agronomic characters. Crop plants will be plagued with new pests and new forms of old ones. New plant types and habits will be needed for ever improving methods of harvesting, processing and marketing. All too frequently the need for new germ plasm may become demanding if a particular crop is to be saved or continued in its region of best adaptability.

The Subsistence Agriculture of Lake Yojoa, Honduras[1]

The region around Lake Yojoa, Honduras' principal lake, is an area below the highlands level but still reasonably cool. This lacustrine area and adjacent mountain slopes demonstrate what may happen to an isolated tropical region when it is "opened" by providing a good and rapid means of transportation.

LOUIS O. WILLIAMS[2]

Honduras, like the other countries of Central America, is primarily an agricultural nation. In common with the neighboring republics it has a rapidly expanding population that must be fed from lands which often have been in agriculture for centuries. The expansion and intensification of agriculture in several parts of Honduras, especially in the relatively cool highlands, have been very noticeable in recent years.

The agriculture of Honduras is of two distinct kinds. Plantation agriculture is practiced along the north coast of the country, in a relatively limited area, where crops of great importance to the economy of the country are grown for export. A relatively small part of the Honduran people is involved in this agriculture, but it is the backbone of the national economy and helps to make possible a stable government. The second kind of agriculture is subsistence agriculture, carried on wherever there are people, but especially in the cooler highlands.

Subsistence agriculture, by its very nature, is exceedingly important, for a large portion of the people of the country get their daily food from it. The manner in which subsistance agriculture is carried out not only is interesting but also is important in the future of the country and its people.

Even before colonial times the people of Honduras congregated in centers of villages. The agriculture that maintained the centers was close by, sometimes as far as a day's travel from the center, but usually much closer. Comayagua and Tegucigalpa have been the two principal centers of population in the highlands, while farther to the west Santa Bárbara, La Esperanza, and the Copans are secondary centers of agricultural settlement. San Pedro Sula is the center and base of settlement on the northern coastal plain area of the country. Minor centers, Choluteca on the Pacific coastal plain, Danlí in south-central Honduras, and a few others of less importance exist.

Traditionally the lands between the centers of population have been sparsely populated, if at all. Possibly the lack of roads and means of transportation have been responsible for this condition. There is little incentive to work and produce more than can be consumed if the excess cannot be bartered in one way or another for goods which cannot be produced. Centers tend to facilitate exchange. The old Spanish custom of living in villages and even, in colonial times, of forcing the

[1] The observations and photographs were made while the author was botanist at Escuela Agrícola Panamericana in Honduras.

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FIG. 1. Lake Yojoa. Most of the clearings on the steep western slopes bordering the lake have been abandoned. The shallow lake-edge in the foreground, which in time will fill and become the agricultural land of the future, is covered with water weeds, sedges and grasses.

Indians to live in settlements rather than scattered over the land may well be one of the reasons why people tend to live in groups even today.

A large portion of Honduras, principally much of the large departments (states) of Olancho and Colón, are beyond the bounds of the effective national territory. Nearly half the land area of Honduras, but possibly less than ten percent of the population, are in these departments. Roads are almost lacking and the sparse population perhaps does not justify an extensive road-building program. The contribution of this vast unsettled area to the national economy is almost nothing. Whether these departments will prove to contain Honduras' most important reserve of agricultural lands, as some Hondurans contend, will be answered by the future.

The road system of Honduras has been developed mostly in the last quarter century and more especially in the last ten years. The network of roads will continue to have a very definite effect on the distribution of people in Honduras. The roads provide easy access to country formerly hard to reach, and what is more important, they make possible the means of transport by which produce may be sent out and other goods brought in. They make commerce possible.

The region around Lake Yojoa, Honduras' principal lake, and perhaps the most beautiful one in Central America, is an area below the highlands level but still where the climate is reasonably cool.

FIG. 2. Preparation for planting manioc (cassava, mandioca, yuca). Stem cuttings with at least one bud provide the "seed" for an interplanting in a recently planted coconut plantation. The two laborers in the back worked only an average 20 minutes per hour.

FIG. 3 (Upper). Eastern shore of Lake Yojoa. Recently abandoned agricultural clearing, with poor quality primary forest in the background.

FIG. 4 (Lower). The largest and best fields near Lake Yojoa, with slopes of the Santa Barbara mountains ten or more miles away. Grass-covered shelters protect both men and harvest.

This lacustrine area and the adjacent mountain slopes demonstrate very clearly what may happen to an isolated tropical, and potentially agricultural, region when it is " opened " by providing a good and rapid means of transportation.

There has been a road of sorts from the railhead of Potrerillos, near the coast, to the highlands for more than 25 years. It was interrupted by Lake Yojoa over which it was necessary to pass by ferry. Within very recent years the road has been greatly improved and the unfinished portion around Lake Yojoa has been completed. Ten years ago it was a rugged two-day trip over the less than 200 miles of road from Potrerillos to Tegucigalpa. The trip can be made comfortably today in seven or eight hours. This improved road has been the main reason for the much increased farm activity around the lake as well as for the increase in the farming population.

I first visited the lake in 1946, soon after the road around the lake had been completed. There was one small, primitive village along the 15 miles or so of this new road, and a few scattered houses. Today there must be more than a hundred houses along or near the road, and the cultivation of land and forest usage have been very greatly augmented.

To the west of Lake Yojoa, on the lower slopes and in the valleys in the Santa Bárbara mountains, agriculture has increased greatly because of the new road, built by a mining company, which connects with the national highway.

The whole lake area is one of agriculture, of a small amount of cattle raising and of forest utilization, with some minor activities. The agriculture is primitive in all of the area which I observed. The only tools which I saw being used were machetes, axes, hoes and planting sticks tipped with metal, and of course, fire. The basic agricultural techniques must be similar to those which the Indians have used perhaps for millenia.

The individual fields were usually rather small, mostly 10 to 20 acres, although there was at least one outstanding field along the lake that must have been 200 or 300 acres. At any given time, there is, of course, more potential farming land resting than in actual use. The ratio of unused or abandoned fields to cultivated fields must be at least five to one, possibly the ratio is higher.

The method of preparing land for planting is similar in the whole region. Most of the level lands near the lake have been cleared previously, often more than once. These lands have grown up into scrub or secondary forest. The new operation is to enter, toward the end of the rainy season, and fell all the trees and brush with either an axe or machete. When the fallen material has dried enough so that the smaller material will burn, it is fired. Fire will not completely clear a field of fallen brush and trees but it will burn branches up to two inches in diameter and gives easy access to the field. The larger logs and stumps are left and ignored; the working of the field will be entirely by hand, not by machinery; so these obstructions hinder operations but little.

Soon after the fire has cleared the field it is usually ready to plant. If the fire thoroughly covered the field, as it usually does, no further cultivation is required. The fire leaves the soil soft and loose. If the firing was not thorough, it may be necessary to turn the soil, usually with a hoe, or rarely with oxen and a crude plow.

The monoculture common in farming lands in the so-called temperate zone is rarely practiced around Lake Yojoa; nor is one crop a year considered sufficient. Very often two crops are sown at the same time, one to mature before the other, as quick maturing beans, and maize which requires a longer time.

The first crop to be sown after clearing the fields depends on the weather

FIG. 5. This eight- to nine-month-old clearing has produced one crop of rice, one of maize, and is being sowed to beans. Six crops (two each of rice, beans and maize) will be produced before the land is abandoned. Men use metal-tipped planting sticks to plant beans. Gourds are used as seed containers.

that is to follow. If the rainy season is due or at hand, as is probably often the case, then the first crop may be rice. This will ripen in due course and is harvested. Almost immediately another planting will be made, usually maize with perhaps an interplanting of beans. The beans should mature quite rapidly and the maize will be mature at about the beginning of the dry season. The dry season (a Kansas farmer would consider the dry season to be a very wet year) is the special season for beans, and the end of December and beginning of January see beans going into the soil all around the lake. Beans will mature in 10 or 12 weeks in the short winter days (the Honduran farmer would call it summer). The year's cycle of crops has been completed and another may be started almost immediately, for it is again time for the rainy season.

The farm lands around Lake Yojoa are mostly cultivated, if planted to subsistence crops as described, for only two years and then abandoned for ten to fifteen years, a rest period that doubtless is being decreased as the population increases and the demand for food is ever greater.

The agriculture of the mountain slopes in the vicinity of Lake Yojoa is similar to that practiced near the lake, with one very important exception, namely, that much of the clearing reaches into virgin forest. The time required for the fields

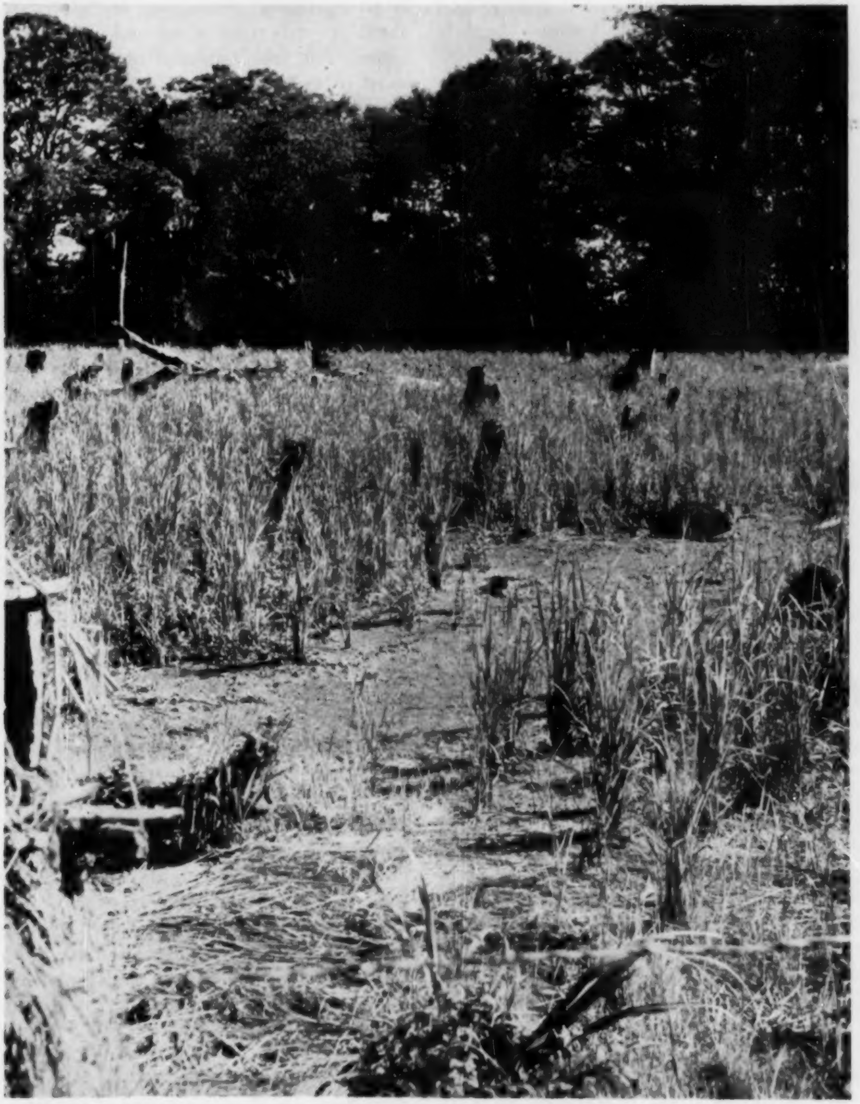

FIG. 6. Recently cleared field at lake level. The crop is rice, and this particular field, recently flooded, probably will remain too wet for any other crop.

on the steep slopes to "recuperate" when they are abandoned is greater and consequently the need for new land is more urgent.

The fields on the mountain slopes deteriorate much more rapidly than those on more level terrain because of the erosion caused by the torrential rains that fall on the recently cultivated and unprotected soil. Leaching by rain and action of the sun in both cases are doubtless important factors in reducing fertility.

Beans, maize and rice are the important crops, but they are not the only ones. In one short period in December I saw and talked to farmers who were planting, cultivating or harvesting the following crops in addition to those mentioned: sugar cane, manioc, bananas, plantains, squash, coconuts and coffee. Cotton and tobacco, non-food crops, were each seen planted in one place.

In addition to the crops that were being grown for food or drink there was some harvesting of the natural forest, either as a primary objective or as a secondary objective in the clearing of land for agriculture.

The greater part of agricultural activity had to do with plants, but there was some animal industry in the area. Cattle, rather abundant, were the principal domesticated animals. Most are raised for beef, but some milk is now being produced. The dooryard animals, of course, are present around most farm houses; pigs and chickens are common, ducks occasional. Dogs are prolific and compete with man for the available food; as in most primitive societies, they are a sad lot.

Hunting and fishing are done, but I was informed that these pursuits are rather unrewarding in comparison with the time and equipment required. Shotgun shells, required for the hunting of birds and deer, are very expensive. There is no regulation of hunting or fishing, so these pursuits may be carried out at any time. The lake contains many fish but most of them are small, one as large as one pound being unusual. Ducks, both migratory and non-migratory kinds, are seasonally abundant on the lake. Game birds that inhabit the old clearings and forest edges are locally abundant and some few are killed for food. Fish and game have little effect on the settlement pattern.

Life is not difficult as far as the climate is concerned, if one does not mind the rain. It is cool in the winter months, but not cold. It can be hot and humid in summer and usually is, but perhaps never so uncomfortable as Washington or New Orleans can be.

Diseases are present; perhaps the most important is malaria. Houses built for the climate of the lake offer little resistance to the entrance of mosquitoes or other insects. Diseases resulting from or aggravated by uncleanly habits are doubtless common. Deficiency diseases, due to malnutrition, are to be seen among the children.

Labor seems to be available for at least the local needs, and the wage paid is average for the country. Relatively great numbers of men are seen working in small fields. They often work slowly and inefficiently, even considering their limited tools. Two fields where beans were being planted were observed. On one of about 15 acres there were five men planting beans, and it took more than seven days for them to do it. In another field, of about ten acres, there were six men (sometimes more) planting beans for five days. A group of men planting manioc did not seem to be actually working more than a quarter of the time. Inefficient labor must make the production of any food crop expensive.

Pakistani Ephedra

A high-yielding, naturally occurring source of ephedrine, Ephedra gerardiana, and a closely associated factory, gives West Pakistan a virtual world monopoly for the naturally produced drug.

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China was the only world source of ephedrine before 1925, but disturbed conditions in that country brought about by the Sino-Japanese War made it necessary to search for other sources. It was found that species of *Ephedra* from different parts of West Pakistan contain as great or greater percentages of ephedrine than those of Chinese origin. The local forest department exported supplies of the drug from Baluchistan for the first time in 1928 to Great Britain and in 1937 to the United States of America. At present, Pakistan has a world monopoly for natural sources of ephedrine. In recent years increasing production of synthetic ephedrine has become a menace to this natural source, but with the establishment of an ephedrine factory near the source of the crude drug at Quetta, and with the availability of abundant cheap raw material, utilization of the natural materials has been made possible for at least the next few years.

Ephedra has been used by the Chinese for the last 5,000 years, but it is rather astonishing that, in spite of its abundance, it was not much used in the indigenous medicine of Pakistan. The only known local use is in intoxicating chewing powders where ashes of *Ephedra* twigs are mixed with tobacco. It is thought that the famous " Soma " drink of the early Aryans was prepared from *Ephedra*, but there is no substantial evidence in support of this contention (1).

Source of Drug

Ephedrine is extracted from the green branches of *Ephedra gerardiana* Wall. In the opinion of the author there is no sound basis for differentiation between *E. gerardiana* and *E. nebrodensis* Tineo, although Qazilbash (3) considers them as distinct species. Whatever differences there are can be correlated with altitudinal and climatic conditions. *E. gerardiana* is found in Baluchistan, Waziristan, Kurram Agency, Khyber, Indus Kohistan, Gilgit, and upper parts of Chitral, Dir, Swat and Kaghan valley at altitudes of 6,000 to 14,000 feet.

In addition to the above species of *Ephedra*, two more are native to West Pakistan. *Ephedra intermedia* Schrenk and Meyer, with a distribution similar to that of *E. gerardiana*, but restricted to heights between 5,000 and 6,500 feet, contains a lower percentage of ephedrine than *E. gerardiana*. It is sometimes used as an adulterant. In very arid areas, *E. intermedia* may extend to 9,000 feet. *E. foliata* Boiss is restricted to the plains and low hills not exceeding 3,000-feet altitudes. It is completely devoid of ephedrine.

Description of the Plant

Ephedra gerardiana is an erect shrub, one-half to six feet tall. The basal stem is three to five inches in diameter, with a thick bark. The green ascending branches, which constitute the drug, have internodes from one-half to one-and-a-

FIG. 1. *Ephedra gerardiana.* Needle-like branches which constitute the drug arise in clumps from the thick woody stem.

FIG. 2. Male and female cone bearing branches of *Ephedra gerardiana.*

FIG. 3. Association of *Ephedra gerardiana* and a young tree of *Juniperus macropoda* in a transitional stage of succession at Ziarat, Baluchistan.

half inches long and five-hundredths to eight-hundredths of an inch in diameter; the internodes are striate with slightly scabrid ridges. Leaves are reduced to teeth-like projections, forming a sheath around the nodes. Female cones, which ripen from October to November, become sweet, fleshy, and reddish at maturity.

Ecological Observations

Ephedra gerardiana is restricted to the arid mountain regions of West Pakistan. A Mediterranean climate prevails in this area, with rains during the winter and spring months. The annual rainfall in the area of the distribution of this species is between five and thirty inches. *E. gerardiana*, being one of the pioneer plants, grows among crevices on bare rocky mountains; in certain places it is almost the sole vegetation. The plants produce dense growth, particularly in the dried river beds at the mouth of the glaciers in alpine and subalpine regions. In open sunny places, the stems are dark greyish-green, with stouter and

rougher internodes, and of greater height than those of plants growing in shade. *Ephedra* plants are eventually succeeded by *Juniperus macropoda* Boiss, *Pinus gerardiana* Wall and *Pistacia khinjuk* Stocks, which constitute the climax vegetation of this region. Plants with suppressed growth may be located under the partial shade of low branches of almost every juniper tree, but under *Pinus gerardiana* they are eliminated. *E. gerardiana* seems to do equally well on limestone and sandstone rocks.

Altitude has a very profound effect on the growth of this plant. At 6,500 feet, it is normal to find shrubs five to six feet tall, with stout branches, but at the upper limit, the plants are usually between one and two feet in height, with more slender branches. The shorter growing period and excessive cold every winter at the higher altitudes kills the tender parts, producing a plant of lower stature.

Ephedra gerardiana starts active growth in spring and forms cones during this period. Growth in summer is dependent on the amount of rainfall during that period. After the shedding of ripe female cones from October to November the plants pass the winter period in the dormant stage. Regeneration is mainly by seeds and to some extent by root suckers.

Active Chemical Constituents

The total alkaloidal content in the dried green branches is 1.0 to 2.5 percent; of this 60 to 70 percent is ephedrine, the rest, pseudoephedrine. A sample with less than 1.0 percent total alkaloid is not accepted in the trade. According to Chopra, the pharmacological action of pseudoephedrine is similar to that of ephedrine.

There are definite periodic variations in the ephedrine content. Three authors (1, 2) state that it is greatest in autumn after the ripe cones have been shed during October and November. In the winter period there is little decrease, but from March onwards the concentration rapidly drops to its lowest point in August. The alkaloidal content starts increasing and reaches a maximum in October and November. The results of Qazilbash (3) show a little different trend in the alkaloidal content: the maximum content is maintained throughout the rest period until spring when there is appreciable decline in alkaloid content associated with active growth. After flowering, gradual increase is maintained throughout the period until maximum is reached in autumn. He maintains that rains only temporarily reduce alkaloidal content.

The female cones, roots, woody stocks and thick branches contain very little ephedrine. Only the green stems have a high content of the alkaloids.

Collecting and Marketing the Drug

At present, the drug is collected only from the Baluchistan region because of the nearness of the source to the ephedrine factory at Quetta, and because of abundant cheap supplies available from this source. All the *Ephedra* growing in Baluchistan is owned by the Forest Department and is collected under its supervision by contractors. Each area is divided into three parts and a three-year rotation is followed. The collecting season lasts from the beginning of October till the onset of winter rains, sometimes to the middle of December. The green branches with woody branches subtending them are cut with sickles by manual labor. No woody stem more than one-half inch in thickness and two inches in length may be cut. The cut material is dried in the open, requiring about 15 days to reduce it by 50 to 60 percent of the total fresh weight. The dried material is beaten with sticks to detach the internodes and is sieved through a mesh, allowing only the internodes to pass. The thick stem pieces are

FIG. 4. *Ephedra gerardiana* growing under *Juniperus macropoda* at Ziarat, Baluchistan.

FIG. 5. *Ephedra intermedia* in the dried bed of Hunza River at Gilgit. It is a common adulterant of the genuine drug.

thrown off. The internodes are packed in double-size gunny bags and stored in a dry place. The finished product should be greyish-green; wetting causes discoloration.

The only possible adulterant is *Ephedra intermedia,* which contains about 0.5 to 1.5 percent of total alkaloids. The internodes of *E. intermedia* may be easily recognized by their greater length and thickness.

Plant material is sold to the ephedrine factory at Quetta for processing. The present annual consumption of the crude drug in the factory is a little below 1,000 tons.

Summary

In recent years, Pakistan has developed its natural resources for production of ephedrine to an extent that it is in a position to meet the entire world demand for this valuable drug. The source of natural ephedrine, *Ephedra gerardiana*, grows over large areas in the region of West Pakistan where a Mediterranean climate with winter and spring rainfall occurs, at altitudes from 6,000 to 14,000 feet. The drug, consisting of green branches, is collected from October to the middle of December when the alkaloidal content is highest. That content varies from 1.0 to 2.5 percent, and is extracted at the factory at Quetta from the drug collected from Baluchistan region.

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Utilization Abstract

Wax from Henequen Bagasse. The Mexican Institute of Technological Research has established a pilot plant at Merida, Yucatan, to extract hard wax from henequen (*Agave fourcroydes*). Bagasse, the waste product left after Mexican sisal fibers have been removed from the leaves, contains a small amount of a high quality wax. There are several difficulties involved in extraction of a satisfactory product: high water content and low wax percentages; a low bulk density derived from the mechanical decorticator; design of concentrating and handling equipment.

The waxes derived from the total waste contain undesirable resins, fatty fractions and pigments, but it has been found that waxes extracted from certain parts of the waste have a light color, high melting point, and excellent gloss. The product compares favorably with carnauba wax. (M. J. Mier y Teran, *Chemurgic Digest 16(8): 9–11. 1957.)*

A Unique Reported Use for the Fruit of *Semecarpus anacardium* L. f. (Anacardiaceae) In Ancient Arabian and Indian Medicine

The use of an extract of the whole or parts of the fruit of Semecarpus anacardium for disorders of the central nervous system is found in several old folk-medicine reports from India and Arabia. Interest in drug plants of possible use in psychopharmacology provides stimulus to investigate and report on the putative values of this product.

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The family Anacardiaceae contains some 700 species distributed among 60 genera. Of the temperate species, the genus *Rhus* contains such poisonous and harmful plants as poison ivy, poison oak, and poison sumac. Food plants are represented by the cashew nut tree (*Anacardium occidentale* L.), the mango (*Mangifera indica* L.) and the pistachio nut (*Pistacia vera* L.).

The genus *Semecarpus* contains some 40 species distributed throughout the tropical regions of the world. *Semecarpus vitensis* Engl., the itchwood tree of the Pacific islands, contains an irritant milky juice. Similar in action is *S. atra* Viell. from the same area. In Australia, *S. australiensis* Engl., the " tar tree ", produces a black tarry sap which upon contact produces a severe dermatitis (27). The crushed bark of *Anacardium rhinocarpus* DC. in Panama is sometimes used as a fish poison (26).

Semecarpus anacardium is known in India as the " marking nut tree ", since a tannin-like substance extracted from the fruit is useful in marking fabrics (9). It has also been termed " Dhobi's nut " (24). About 50,000 tons of nuts containing about 20 percent bhilawan oil appear to be available each year (2). It is a deciduous tree, some 50 feet in height, of the sub-Himalayan tract, from the Sutlej eastward, ascending to an altitude of 3,500 feet, and found throughout the hotter parts of India as far east as Assam. It does not occur in Burma or Ceylon, but is distributed through the Eastern Archipelago and North Australia (30).

Dymock (7) has provided an extensive description of this nut: " The marking nut is well described by the Arabs as resembling the heart of an animal, the torus representing the auricles, and the fruit the ventricles; in the dry commercial article the torus is seldom present, and the fruit is of the size and shape of a broad bean, of a black color, and quite hard and dry externally, but upon breaking the outer skin with a knife the central cellular portion of the pericarp will be found full of a black oily acrid juice; inside the pericarp is a thin shell conforming to it, and containing a large flat kernel, which has no acrid properties ".

Synonyms for this species include *Anacardium orientale* Auct., *S. latifolius* Pers., *Anacardium latifolium* Lam., and *A. officinarum* Gaertn. Long lists of vernacular names in the various Indian and Arabic dialects are given in the works

of Drury (6), Dymock (7), and Kirtikar and Basu (15). The drug from *Semecarpus* is generally known by the older name, Anacardium.

The unique use referred to has been located a number of times in the technical literature, and once in a literary or historical reference. An early one is that of Honigberger (13), a physician to the court of Lahore, who states that this drug was " now official in the East only, though formerly used in Europe. It is kept in all bazaars. The Hakims administer it for weakness (shortness) of memory, epilepsy, catalepsy, etc.". He does not specify the exact portion of the fruit or accessory parts that were thus utilized. Nadkarni (20) states that for the Unani it " improves memory ".

Watt (30) states, " The kernels of the nuts are also eaten. They are supposed to stimulate the mental powers, especially the memory ". These kernels were also stated to contain a small quantity of sweet oil. Hill (11) records that " The Arabians have said great things in praise of the *Anacardium;* they tell us it strengthens and comforts the brain, restores the injured nerves to their true state, and even assists the memory ".

The reference by Sen (24) is not so specific, since it refers to an improvement in mental health rather than to the unique memory aspects following prolonged use of the drug in suitable doses.

The historical reference given is that relating to the celebrated Arab historiographer, Al-Baladhuri, " who died in 892 A.D. mentally deranged from an overdose of *Anacardia,* an Indian fruit thought to strengthen the memory. His name comes from this curious Marahnut (Baladhur) " (12, 21). Knowledge of this fruit goes far back into antiquity—Wittstein (31) indicating it was the " golden acorn " (Chrysobalanos) of Galen (A.D. 130–c. 200) and that Paulus of Aegineta (fl. A.D. 300), Avicenna (d. A.D. 1037) and other Arabic physicians were familiar with it. Adams (1) states that Serapion, Rhases, and Avicenna recommend it in mental disease, especially in loss of memory, and that it is briefly noted by Myrepsus and Actuarius.

Of the sources examined, some works mention this unique use but provide no case histories; others omit entirely any reference to this use, and only the work of Fée (8) passes judgment: " That which is told about the marvelous properties of Anacardium for reestablishing the memory and facilitating perception of ideas, should be relegated among the fables ".

On the other hand, Drury (6) reports that " the kernels are rarely eaten. The pure black acrid juice of the shell . . . is employed by the Telinga Physicians " for skin disorders, etc. Watt (30) further states that in Mohammedan works of medicine it was used in diseases of the nervous system. Later 19th and 20th century pharmaceutical works or translations of older works generally appear to omit reference to this specific usage—e.g., Chakraberty (4), Dymock (7), Meyerhof and Sobhy (18), Zimmer (33), and Chopra and Chopra (5). The latter authors do state that the pericarp of the fruit contains 20 percent of an oil which gives bhilawanol and other compounds and that no systematic investigations have been carried out to determine its beneficial effects in disease. A number of publications (16, 24, 28, 29) have dealt with the general subject of *Anacardium* poisoning. Several chemical studies have been made on this and related species, especially of the fruits (3, 10, 23, 25). The possibly useful publications of LeClerc (17) and of Peckolt (22) unfortunately were not available for study.

Other authors have mentioned its use in the treatment of palsy (15) and of facial paralysis (20). That the drug, or certain components of the whole or parts of the *Semecarpus* fruit, has a profound

effect upon the central nervous system, thus seems quite probable.

From the older literature available and the negligible amount of modern scientific work on this drug, it is readily apparent that the highly irritant and poisonous properties have greatly restricted its use and its further exploration and analysis. With modern techniques of separation and characterization, the useful components may possibly be separated from the less desirable fractions and studied chemically and pharmacologically.

In view of the history of the remarkable drugs from *Rauwolfia* spp. (Apocynaceae), long used in the Ayrudvedic medicine of India and now finding application for treatment of hypertension (14, 19, 32), it would appear worthwhile in this case to pause and examine critically the claims for *Semecarpus*, as well as to provide additional documentation for these curious uses from the ancient and the more modern treatises in both Arabian and Indian medicine.

This article is offered with the same skepticism yet interest that the editor of the Indian Medical Gazette indicated in a footnote to Sen's (24) article of 1902: " In view of the present interest taken in the use of indigenous drugs we publish the above article. If further investigation proves this drug to have even a tithe of the good qualities claimed for it by the above writer, it will prove a valuable addition to our resources ". We hope now after 55 years that more will be done to clarify the actions of this drug than apparently was accomplished after this editor's appeal.

Zimmer (33), in his lectures on Hindu medicine, stated, " The efficacy of drugs was more or less a matter of faith, based on ancient usage and previous experience, as such methods prevail among shepherds and old women: yet the doctors professing Hindu or medieval medicine had passed examinations and were of the educated and intellectual classes ". In a later section (p. 90) in discussing one of the eight parts of medical wisdom, " rasāyana ", Zimmer includes " improving memory " as one of several goals of this particular class of medical practice. The Indian materia medica is a very rich one, containing some 1600 plant drugs according to Chopra and Chopra (5).

Following a critical examination of additional reports, if such can be located, it would be opportune to conclude whether there is any valid basis for these unique claims, or whether they should be dismissed as superstitious folklore without any substantiation of fact. Certainly the experience of an ancient practice should be critically examined by the methods of modern experimental science to determine whether any use can be made of these alleged properties in the relatively new science of psychopharmacology.

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Rice Fermentation in Ecuador[1]

Fermented rice, or "Sierra rice", of Ecuador, is distributed and consumed exclusively in the Andean Sierra. Fermenting precooks the rice, thus reducing the cooking time in the Andean Highlands. "Sierra rice" is the only type used in preparation of "dry rice", which is considered indispensable to all meals.

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Agricultural produce has been subjected to fermentation processes by primitives, such as the Philippine Igorots and the Fon, Goun, and Yoruba tribes of Africa (1), as well as by modern societies of industrialized economies. Rice, in particular, has been fermented in many parts of the world—notably in India, China, Indonesia, and Japan (11)—into alcoholic beverages in the form of whiskey (3), wine (6), and beer (2). In Ecuador, however, rice is fermented, not into a beverage, but rather as a main item in the diet of the Andean populace.

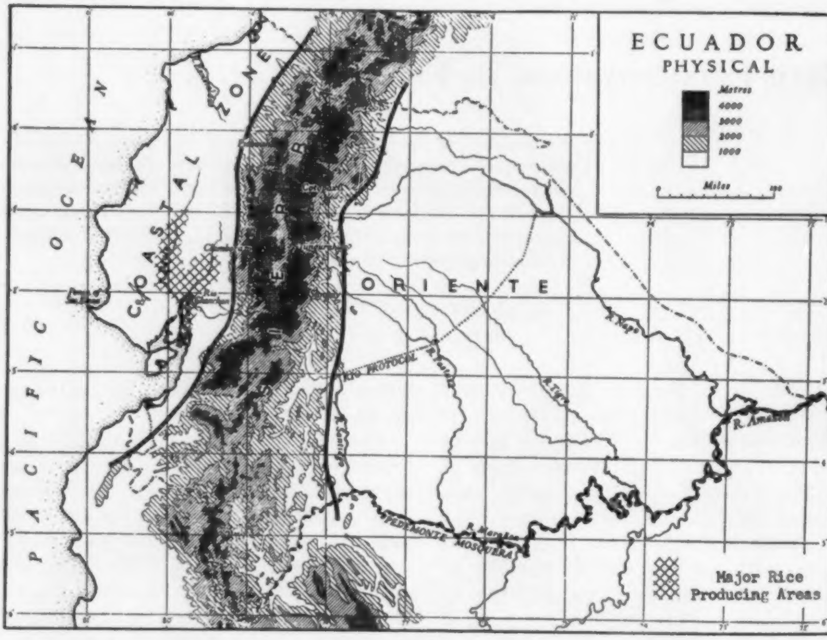
Ecuador's first population census, completed in November 1950, recorded 3,202,757 inhabitants. Of these, 40.5 percent lived in the coastal plains sloping westward toward the Pacific from the Western Cordillera; 58.06 percent was distributed within the Sierra, which embraces the Western and Eastern Cordillera and the inter-Andean valley between those mountain ranges; 1.4 percent dwelt in the Orient stretching eastward from the Eastern Cordillera to the Amazon; and 0.04 percent inhabited the Galapagos Islands (9, Table 1). These physiographic divisions are shown on the accompanying map.

Although the 1950 census did not include an ethnic classification, some concept of racial distribution may be gleaned from a government publication issued in 1944 which estimated that two years earlier ten percent were Whites, 39 percent Indios, 41 percent Mestizos, 5 percent Negroes and Mulattos, and the remaining 5 percent "other" races (7, p. 11). However, unofficial estimates have held the Indio population to be predominant.

Of the total population, 38.6 percent was considered economically active (9, Table 13). The importance of agriculture to Ecuador's economy is revealed by the fact that in 1946 it was estimated that 63 percent of the economically active people were engaged in agriculture, hunting, and forest exploitation, which, together with mining (employing one percent of the economically active), accounted for 48.7 percent of the total national income (7, p. 9).

In 1945, agricultural products comprised 65.6 percent of total export values; by 1952, they had climbed steadily to 91.2 percent (7, p. 140). Commodities shipped abroad included balsa wood, bananas, cocoa, coffee, rice, rubber, and tagua nuts, and in addition kapok, dye-woods, livestock, and straw hats.

[1] The author is indebted to Professor Karl Brandt, Associate Director of the Food Research Institute of Stanford University, and to Señor don Guillermo Alban Gonzalez, former Director del Departamento de Asuntos Economicos, Ministerio de Economia, Republica del Ecuador, for valuable criticism and assistance.



Geographical Regions of Ecuador. Adapted from Lilo Linke, *Ecuador, Country of Contrasts* (Royal Institute of International Affairs, Chatham House, London (Oxford University Press), 1954), p. x.

The significance of rice to Ecuador as an item of international trade may be discerned from the fact that among the five foremost exportable commodities, rice accounted for 38.1, 45.7, and 14.0 percent of their value in 1940–44, 1944–48, and 1948–52 respectively (7, p. 141).

Domestic consumption has remained fairly stable over the past ten years at between 800,000 to 850,000 bags (of 100 pounds of milled rice each) per year. Acreage and yields, however, have fluctuated quite sharply with climatic conditions and changes in international trade. Most of the local market caters to the coastal inhabitants for whom rice, in a hard-milled, white state, forms the mainstay of their diet. A considerable segment of the trade, however, is destined to the production of an intentionally fermented rice. This product is distributed and consumed exclusively in the Andean Sierra, and is known as " Sierra rice ", while the regularly-milled rice is called " White rice ".

" Sierra rice " is used exclusively in the preparation of " dry rice ", which is considered indispensable to all meals. " Dry rice " is prepared by cooking the kernels until they separate evenly. Inasmuch as fermentation already precooks the rice by subjecting it to temperatures of 50 to 80 degrees C., " Sierra rice " requires less cooking time in the Andean altitudes where water boils below 100 degrees C. " Dry rice " is distinguished from white " soup rice " and " wet rice " in that the latter are cooked to a mushier consistency than the former.

Fermentation is induced by dumping

moist rice on large cement or cane floors out in the open, and covering it with tarpaulins. This produces a rather pungent, unpleasant odor which permeates the grain. While this aroma appears to diminish once the rice is dried and milled, it seems to return to some degree when the rice is being cooked. The rice normally used for this process is grain which already has a relatively high moisture content when brought to the mills from the fields. Otherwise, dried rice will be wetted. Rice with a 22 percent moisture content begins to ferment in three days, while it takes up to ten days for rice with a moisture content of 17 percent to ferment. Once fermentation sets in, the rice is left under tarpaulins for four or five days. Then laborers remove the tarpaulins, replacing them after turning the rice with shovels. At a decreasing rate, the rice continues to ferment; six to fifteen days elapse, depending on relative humidity and temperature, before the rice is turned once more and left to dry in the open.

Samples are gathered daily during fermentation to control the coloring of the rice. The hulls turn a cinnamon color, the shade becoming darker the longer fermentation proceeds. Individual kernels of fermented milled rice, on the other hand, range in color from golden to deep cinnamon brown. The most acceptable color to the trade is golden or light cinnamon. Turning the rice while it ferments not only retards that process, but also assures more uniform coloring. Excessive or spotty fermentation produces black rice unfit for sale.

Inasmuch as varieties characterized by slender ligneous integuments ferment more easily, so-called "Fortuna" and "Carolina" varieties are preferred. Occasionally, shortage of supply of these varieties will cause "Chato-Canilla" (of a thicker integument) to be used.

In the milling process, fermented rice is more susceptible to breakage, especially when fermentation is induced by moistening dry rice. While "Sierra rice" is not highly polished, yields of between 32 and 40 percent brokens (kernels smaller than three-fourths of the whole grain) considerably exceed those of hard-milled white rice. This does not present a serious marketing problem, however, because the trade accepts rice with up to 35 percent brokens. In fact, the greatest demand is for low-priced rice—hence for rice containing a large percentage of brokens.

The major problem in producing "Sierra rice" is the danger of its being mixed with white rice, because the same physical facilities are used to process both.

One large mill reports that normally 20 percent of its total production will be destined to "Sierra rice". This proportion will vary to the extent that, in the absence of mechanical driers, inadequate sun-drying forces other mills which do not normally ferment rice to offer it in competition with the regular sources of supply.

"Sierra rice", which is packed in 12-ounce second-hand sugar bags made of hessian cloth similar to the containers used for white rice, usually commands a premium of 5 to 6 sucres above the price of regularly milled white rice. This is considered a reasonable return on the additional labor costs incurred by the fermentation process. In wet years, however, when more rice is accidentally fermented than would have been intentionally subjected to that process, the market drops appreciably. For example, in 1953 "Sierra rice" sold for 10 to 20 sucres below the price of white rice.

The fermentation technique described here has been compared with the Asian process of parboiling. Parboiled rice, as defined by the International Rice Commission, is produced by pounding or milling rice which has been steeped in water, afterwards steamed or heated, and then

dried (4). This process permits water-soluble nutrients to diffuse from the pericarp and aleurone layers into the endosperm of the kernel. It would be interesting to determine to what degree fermentation enhances or destroys the nutrients of the original grain, since many of the organisms of the fermenting mass have the capacity to produce certain vitamins, such as riboflavin, while the content of other vitamins, possibly thiamine, might decline.

Parboiling also improves the milling quality of the rice by reducing the degree of breakage in the milling process, while fermentation seems to produce the opposite effect. Inquiries of competent authorities have failed to reveal evidence of rice fermentation, as practiced in Ecuador, in other Andean regions of South America.

Rice, however, is only one of the many commodities subjected to fermentation. Others include sorghum, maize, millet, cassava flour, honey, bamboo and palm saps (8), potatoes (10), tobacco (5), cucumbers, cabbage, tomatoes, cane sugar, apples, grapes, and olives.

Yet each food commodity presents a challenge; the more that is known about their processing, the better are the chances for improving the level of nutrition of those who consume them.

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Comparison of Dehydrated Plants in Their Ability to Prevent Scale in a Sea-Water Evaporator

Addition of dehydrated alfalfa can eliminate the formation of scale in a sea-water evaporator. This article compares the scale-preventing ability of each of four dehydrated plant species, to the previously proven ability of dehydrated alfalfa.

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An earlier publication (1) proved that the addition of 0.1% of dehydrated alfalfa (*Medicago sativa*) to sea water before it was evaporated, prevented the production of scale in an evaporator if the 50% " blow down " principle was adhered to. This paper reports the result of a study of quantitative experiments designed to compare the scale inhibitive property of dehydrated alfalfa stems and leaves, with that of the dehydrated leaves of corn, buckwheat, oats and pea. The leaves from these species were dehydrated, pulverized in a ball mill and consequently added one sample at a time to synthetic sea water (pH 8.0 to 8.05).

A numbered plate of Admiralty metal, an alloy of 70% copper, 29% zinc and 1% tin, commonly used in the construction of sea-water evaporators, was bent into a $\sqcap$ shape. The dimensions of all plates used were 6.5 by 10.5 cm. The plates were cleaned with warm acid, washed with distilled water and boiled repeatedly in distilled water until their weights became constant within two-tenths of a milligram.

A weighed plate was placed in a 1000-ml. beaker containing 700 ml. of sea water. The water was heated until the volume was reduced to 350 ml. The remaining water was discarded, to simulate the 50% " blow down ". 700 ml. of fresh sea water was added to the beaker and the process was repeated. Ten boilings were conducted for each test; in this manner 7000 ml. of sea water was concentrated to 3500 ml. in the presence of a weighed plate of Admiralty metal. The plate was removed and thoroughly washed with distilled water, dried and weighed. Any gain in weight would be the weight of the scale formed while the sea water was concentrated to half volume. Any loss in weight would be due to corrosion of the metal.

The sea water used was artificial, since the natural sea water available was greatly contaminated with iron hydroxide. A prepared sea water would always have the same pH and the same chemical composition. The formula of Brujewicz (Subow) was used (2). This formula is:

Sodium chloride	26.518	g./kg.
Magnesium chloride (anhydrous)	2.447	"
Magnesium sulfate (anhydrous)	3.305	"
Calcium chloride (anhydrous)	1.141	"
Potassium chloride	0.725	"
Sodium bicarbonate	0.202	"
Sodium bromide	0.083	"
Distilled water	sufficient to make one liter of solution	

Alfalfa Experiments

The protein content of the dehydrated alfalfa used in these tests was 15.20%. Dehydrated alfalfa was added to dis-

tilled water and to sea water before either was concentrated to half volume by the method previously described. As a check, sea water with no additive was also concentrated to half volume by the same method.

The following are the data on these concentrations:

Amount of alfalfa used ..	7 grams in 7,000 ml. of water
Weight of plate placed in 7,000 ml. of distilled water containing 0.1% of dehydrated alfalfa	74.7627 g.
Weight of plate after 7,000 ml. was concentrated to half volume	74.7500 g.
	0.0127 g. loss of metal
Weight of plate placed in 7,000 ml. of sea water containing 0.1% of dehydrated alfalfa	72.6736 g.
Weight of plate after 7,000 ml. of sea water was concentrated to half volume	72.6566 g.
	0.0170 g. loss of metal
Weight of plate placed in 7,000 ml. of sea water with no additive	74.5909 g.
Weight of plate after 7,000 ml. of sea water was concentrated to half volume	74.6329 g.
	0.0420 g. scale formed

Corn Experiments

The protein content of the dehydrated corn leaves used in these experiments was 10.00%. The dehydrated corn was added to distilled water and to sea water before each was concentrated to half volume. The amount of corn used in the various experiments was altered to meet the conditions wanted.

The following are the data on these concentrations:

Amount of dehydrated corn used	7 grams in 7,000 ml. of water
Weight of plate placed in 7,000 ml. of distilled water containing 0.1% of dehydrated corn	71.8748 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	71.8515 g.
	0.0233 g. loss of metal
Weight of plate placed in 7,000 ml. of sea water containing 0.1% of dehydrated corn	74.1283 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	74.1061 g.
	0.0222 g. loss of metal
Weight of plate placed in 7,000 ml. of sea water with no additive	68.9188 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	68.9542 g.
	0.0354 g. scale formed
Amount of corn added ..	5.25 grams to 7,000 ml. of sea water
Weight of plate placed in 7,000 ml. of sea water containing 0.075% of dehydrated corn	49.3429 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	49.3450 g.
	0.0021 g. scale formed
Amount of corn added ..	3.5 grams to 7,000 ml. of sea water
Weight of plate placed in 7,000 ml. of sea water containing 0.05% of dehydrated corn	71.0814 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	71.1103 g.
	0.0289 g. scale formed

Buckwheat Experiments

The protein content of the dehydrated buckwheat used in these experiments was 8.20%. Dehydrated buckwheat was added to distilled water and to sea water before they were concentrated to half volume.

The amount of dehydrated buckwheat used	7 grams to 7,000 ml. of water
Weight of plate placed in 7,000 ml. of distilled	

water containing 0.1% of dehydrated buckwheat	47.4694 g.
Weight of plater after 7,000 ml. was concentrated to half volume	47.4553 g.
	0.0141 g. loss of metal
Weight of plate placed in 7,000 ml. of sea water containing 0.1% of dehydrated buckwheat ...	59.7412 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	59.7332 g.
	0.0080 g. loss of metal

Oat Experiments

The protein content of the dehydrated oat foliage used in these experiments was 4.8%. Dehydrated oat foliage was added to distilled water and to sea water before they were concentrated to half volume.

The amount of dehydrated oat foliage used	7 grams in 7,000 ml. of water
Weight of plate placed in 7,000 ml. of distilled water containing 0.1% of dehydrated oat foliage	58.2025 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	58.1952 g.
	0.0073 g. loss of metal
Weight of plate placed in 7,000 ml. of sea water containing 0.1% of dehydrated oat foliage ...	73.7895 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	73.8113 g.
	0.0218 g. scale formed

Pea Experiments

The protein content of the dehydrated pea foliage used in these experiments was 19.20%. The dehydrated pea foliage was added to distilled water and to sea water before they were concentrated to half volume.

The amount of dehydrated pea foliage used	7 grams in 7,000 ml. of water
Weight of plate placed in 7,000 ml. of distilled water containing 0.1% of dehydrated pea foliage	74.3774 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	74.3687 g.
	0.0087 g. loss of metal
Weight of plate placed in 7,000 ml. of sea water containing 0.1% of dehydrated pea foliage ..	71.7232 g.
Weight of plate after the 7,000 ml. was concentrated to half volume ..	71.7114 g.
	0.0118 g. loss of metal

Conclusions

1. All the dehydrated plants tested diminished or prevented the formation of evaporator scale.

2. Only the dehydrated oat foliage did not completely prevent formation of scale at the concentration of 0.1% of additive.

3. Assuming that the plant that showed the greatest power of corroding the metal to be the best " anti-scale " agent, we must list the plants in the following order of decreasing " anti-scale activity ": corn > alfalfa > pea > buckwheat > oats.

4. Listing the same five plants in their decreasing order of total protein content: pea > alfalfa > corn > buckwheat > oats. This does not exclude the possibility that the " anti-scale " ingredient is protein.

5. Dehydrated foliage of corn, alfalfa, pea, and of buckwheat has the ability of completely preventing the formation of evaporator scale if the 50% " blow down " principle is adhered to and if the additive concentration is 0.1%.

Literature Cited

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2. Sverdup, H. V., Johnson, M. W., and Fleming, R. H. The Oceans. 1946. [page 186].

The Insecticidal Property of Petals of Several Common Plants of India

Kerosene extracts of petals of several species of flowering plants demonstrate insecticidal properties equivalent to or better than that of 11% Pyrethrum extract, a standard insecticide against indoor insects.

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On a previous occasion (1) the author tested the efficacy of 11% kerosene oil extracts of dried petals of 12 species of common plants of India against the rice weevil (*Sitophilus oryzae* L.) and found that the average mortality rate of weevils sprayed with many of the extracts was higher than when sprayed with kerosene oil only.

In the present series of tests, fresh petals of a number of common plants were employed. 1.1 gm. of fresh petals were ground well in ten cc. of white kerosene oil in a laboratory mortar. (This is equivalent to one pound of flower material in one gallon of oil, the same proportion used in preparing Pyrethrum extract for spraying in grain godowns). This extract (11%) and/or its dilutions (5.5%, 2.75%, and 1.375%) were directly sprayed on the test insects.

For each trial a definite number of weevils was collected in a tube from a general culture maintained in laboratory jars. The insects were introduced in the middle of a Petri dish lined with a disc of filter paper. The dish was immediately changed into a vertical position, 18 inches from the tip of the nozzle of a "Holmspray" atomiser containing the extract, and a one-stroke spray of the extract directed to the centre of the dish. The sprayed insects were quickly transferred with a camel-hair brush to a tube containing a few sorghum grains. They were examined 24 hours and 48 hours after treatment, dead weevils separated from live ones, and the latter put back. In each case an equal number of weevils was sprayed with kerosene oil as control.

Extracts were stored in an open place in glass flasks. A brew was used for three to four months after preparation without any appreciable deterioration being apparent.

In Table I average percentages of mortality of weevils, 24 hours and 48 hours after spraying with different strengths of the various extracts, are given, along with the number of insects employed. Corresponding figures for the kerosene oil controls are also furnished.

The data show that the 11% and 5.5% extracts caused significantly high mortality percentages of *Sitophilus oryzae;* 2.75% extracts have been fairly effective in some cases, while 1.375% extracts were disappointing. This incidentally

TABLE I

MORTALITY PERCENTAGES OF *Sitophilus oryzae* SPRAYED WITH FLOWER EXTRACTS IN KEROSENE OIL

Sl. No.	Extract	Family	Percentage strength of extracts	No. of tests	No. of weevils	Percentage mortality after	
						24 hours	48 hours
1.	*Tecoma indica*	Bignoniaceae	11	20	400	70.7	86
			5.5	5	100	69	78
			2.75	4	80	17.5	27.5
			1.375	2	40	15	52.5
2.	*Calotropis gigantea*	Asclepiadaceae	11	8	160	60	92
			5.5	4	80	82.5	90
			2.75	4	80	70	82.5
			1.375	2	44	25	43.2
3.	*Canna indica* (orange)	Scitamineae	11	11	220	59	83
			5.5	11	220	84	92
			2.75	4	80	22.5	33.7
			1.375	2	40	15	62.5
4.	*Canna indica* (rose)	Scitamineae	11	10	200	60.5	75
5.	*Canna indica* (pink)	Scitamineae	11	10	200	43	74
			5.5	2	40	97.5	97.5
			2.75	2	40	97.5	100
6.	*Poinsettia pulcherrima* (bracts)	Euphorbiaceae	11	8	160	58.7	93
			5.5	2	40	55	80
7.	*Cassia* Sp.	Papilionaceae	11	10	200	67	78.5
			5.5	3	60	70	81.6
			2.75	2	40	70	87.5
8.	*Poinciana regia*	Leguminosae	11	5	100	55	53.3
			5.5	5	80	78.7	86.6
			2.75	3	40	62.5	95
			1.375	3	40	42.5	70
9.	*Crotalaria juncea*	Leguminosae	11	17	340	67.6	76
10.	*Argemone mexicana*	Papaveraceae	11	5	100	50	90
11.	*Bougainvillea*	Nyctaginaceae	11	7	140	75.7	92.8
12.	*Nerium odorum* (rose)	Apocynaceae	11	4	80	83.7	100
13.	*Hibiscus rosa-chinensis*	Malvaceae	11	4	80	68.7	97.5
CONTROL							
	Kerosene oil		....	18	360	24	55
	Pyrethrum	Compositae	11	21	300	67.6	75.3 (Earlier trials)

proves the existence of an insecticidal principle in these extracts. Some of the extracts are similar in lethaltiy to 11% Pyrethrum extract, a standard insecticide against indoor insects, while a few surpass it.

The effect of floral extracts on field insects is under investigation.

The lower rate of insect mortality previously obtained with dried flower extracts, as shown in Table II, probably indicates that the insecticidal principle deteriorates when the petals are dried in the sun.

A statistical analysis of small samples on the basis of Paterson's method, using

TABLE II

Comparison of Rice-Weevil Mortality Caused by Dry vs. Fresh Floral Extracts

Extract	Dry or fresh	Percentage of mortality after	
		24 hours	48 hours
1. *Cassia*	Dry	46.5	67.7
	Fresh	67.0	78.5
2. *Poinciana*	Dry	32.7	56.6
	Fresh	55.0	53.3
3. *Bougainvillea*	Dry	60.0	68.9
	Fresh	75.7	92.8

Fisher's " t ", has been made. The mortality rates of all the extracts, compared to controls, are seen to be highly significant.

Grateful thanks are due to Dr. M. Puttarudriah, Government Entomologist for encouragement and advice and to Messrs. D. P. Ramanna and K. N. Narayanaiah, field assistants for assistance rendered.

Reference

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BOOK REVIEWS

An Introduction to the Botany of Tropical Crops. L. S. Cobley. 357 pp. Longmans, Green and Company. $7.25.

There are few comprehensive treatments of tropical crops; this book, therefore, addressed to agricultural students and to workers in agriculture, fulfills a definite need. It might be addressed to anyone interested in a good résumé of information on tropical crops. The author's style is pleasant, and never dull. A basic understanding of botany is all that is necessary for comprehension. The 82 photographs and 66 line drawings are of good quality. Each chapter is supplied with an adequate number of references, and a general bibliography is furnished at the end.

The author's experience in teaching tropical crop botany at the University of Khartoum, Sudan, and travels in tropical regions of the world provide the basis for this text.

The crops discussed are classified under the headings of cereals, fibers, oil-seeds, pulses, root crops, spices, beverages and drugs, fruits, vegetables, rubber and essential oils. This utilization classification is employed rather than a botanical classification because " the student gains little appreciation of the inter-relationships of the different families, nor of the evolutionary trends exhibited by such a system ". It is unfortunate that a list of the plants discussed is not added, giving the groups according to family, genera and species. A discussion of vegetable gums is omitted, as are several other crops of potential value because of space limitation. One or two errors were noted, but these are minor, and are not typical of the book.

Under each heading a few introductory paragraphs discuss the importance of the tropical plants as sources, the methods of commercial classification, the parts of the plants utilized, the most suitable environments, and the countries of greatest production. The most important crop of that category, or the one for which most data are available, follows. The floral and vegetative morphology, the taxonomic categories, if known, method of preparation for use or export, and other information, depending on the importance of the crop, are generally included. One factor is very evident in the discussion of the crops: statements occur frequently that the botanical classification is not adequate or has not been studied. Many of the plants are well known agronomically, but are still lacking an adequate system of nomenclature.

El Ajonjolí en Venezuela. Bruno Mazzani. 77 pages. Caracas: Biblioteca de Cultura Rural. 1957.

Oil producing plants are of great importance in all agricultural economies, both for the expressed or extracted oils and for the by-products, either the " cake " or other portions of the plant. In tropical countries, the oil-yielding plants have high significance as much for their by-products as for their principal product. This is particularly true if the cake has a high protein content and is edible by cattle without further treatment. Sesame is one oil-yielding plant with these valuable characteristics.

Sesame, produced in portions of the old world for centuries, has been well received in the new world, and this agricultural monograph of seven varieties of *Sesamum indicum* in culture in Venezuela demonstrates the present acceptance of this crop. Morphological characteristics of the varieties, keys for differentiation, the most outstanding cultural characteristics, and other useful data are presented. The monograph is of value to anyone in any area of the Caribbean interested in the agricultural possibilities of sesame.

Experiments with artificially induced polyploid plants showed that there was no advantage of tetraploid over diploids as far as total yield of oil is concerned. Reports of work with tetraploid indehiscent forms is, however, of high importance. Much of the seed of the normal dehiscent forms may be lost in harvesting. Results of crossing *Sesa-*

mum indicum with *S. prostratum* and *S. radiatum* are inconclusive, although generally the progeny were less useful agriculturally than were diploid or tetraploid races of *S. indicum*.

Of the varieties grown in Venezuela, "Aceitera" is the most valuable in terms of maturation time, production and average freedom from disease. Other varieties may, however, be more appropriate to certain growing conditions.

Bamboos of the Genus Phyllostachys under Cultivation in the U. S. F. A. McClure. Agriculture Handbook No. 114, U. S. Department of Agriculture. 1957.

The handbook provides a detailed key, based upon vegetative characters, to thirty-four entities of the genus *Phyllostachys* that have been successfully introduced into the United States. The key is designed to be used in the spring-time, when the young shoots are actively growing. The critical portions of the plants are clearly illustrated in a series of photographs and line drawings. Of the thirty-four entities, twenty-four are species and ten are horticultural variations designated as cultivars. One cultivar was added to the treatment after the key was completed.

A description of each entity, based upon living specimens, is included. The descriptions also contain information about introduction into this country, cultivation, and in some instances, related species. All of the plants included in the handbook are native to China.

At the end of the handbook is a list of the specific names of *Phyllostachys* and the corresponding Plant Introduction accession numbers. Conversely, a list of Plant Introduction numbers and the corresponding entities of *Phyllostachys* is also included.